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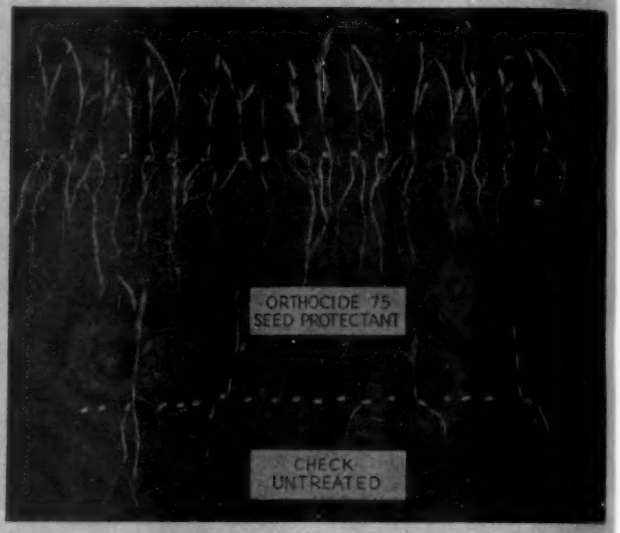

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IN COMMEMORATION: ISAAC-BÉNÉDICT PRÉVOST

1755–1819

WHEREAS, the year 1955 marks the 200th anniversary of the birth of Isaac-Bénédict Prévost, and

WHEREAS, his discovery of the immediate cause and a means of prevention of the bunt disease of wheat gave to the world a key to understanding the causation and the prevention of infectious diseases, and

WHEREAS, this discovery ranks high among the great pioneering advances in science,

THEREFORE, BE IT RESOLVED

That the American Phytopathological Society express its deep sense of appreciation of the selfless devotion and the epochmaking contribution of this modest man who was denied in his lifetime the appreciation that he so richly deserved, and

That a biographical sketch of Prévost and an evaluation of his memoir on bunt be published in Phytopathology.

The foregoing resolution was unanimously adopted by the American Phytopathological Society at its 47th Annual Meeting at Atlanta, Georgia, December 28, 1955.

ISAAC-BÉNÉDICT PRÉVOST [1]

1755–1819

G. W. Keitt

BIOGRAPHICAL SKETCH [2]

Bénédict Prévost came of an old, intellectual family of Geneva, Switzerland. His parents, Jean-Jacques and Marie-Elizabeth Henri Prévost, were people of admirable qualities but limited means. They had two children, Isaac-Bénédict, born at Geneva, August 7, 1755, and a daughter, who died, unmarried, in early womanhood.

Bénédict's early education was very irregular. He had little inclination for the studies of grammar school, and was placed in a boarding school of a small neighboring village, where he received only very limited instruction. He undertook successively two apprenticeships, one in engraving and the other in commerce. He gave up the latter, which offered flattering prospects, to cultivate the sciences. In October, 1777, at the age of 22, he accepted the position of tutor of the sons of M. Delmas of Montauban, Département du Lot, France. This city came to be his second home, to which he was held for the rest of his life by ties of friendship and by congenial opportunities for study and teaching.

At the time of his arrival at Montauban, Prévost had acquired little science; but he was very apt in learning it and had especial talent and taste for mathematics. His progress was rapid. After two years he formed and announced the intention of devoting himself entirely to his studies. Though the very attractive positions of his cousin, Pierre Prévost, at Berlin were open to him when the former resigned to return to Geneva in 1784,[2] he preferred the friendships and the work that had become so dear to him at Montauban. He then persuaded his friends to refrain from seeking further offers for him.

The earlier phase of his studious career was concerned chiefly with mathematics. Physics and natural history dominated later.

In the study of natural history he had many obstacles to overcome, but he also enjoyed some peculiar advantages. He spent part of the year in the country, the principal theater of his observations. There he found, in his adopted family, friends who shared his tastes and took pleasure in furthering his work. But the number was limited, and even in the city he did not find all the help that might have favored his enterprises. He had difficulty in procuring the books that he needed. The irregularities of his early studies served, perhaps, to arouse his curiosity; but they slowed his progress. He supplied by his genius and enthusiasm what he lacked in this regard, and his generous efforts were crowned by success.

His relations and literary correspondence multiplied. His correspondence with his cousin Pierre Prévost was never interrupted and became for both a source of gentle and useful pleasure. At Montauban he was affiliated with *l' Académie du Lot*, of which he was one of the founders. He enjoyed the friendship of many members of this learned society. He had continuing relations with the able astronomer le Duc la Chappelle, among others. His pupils became his friends. At Geneva, MM. Le Sage, Senebier, Jurine, Gosse, Huber, and Maunoir corresponded with him. He was a member of *Société de Physique et d'Historie Naturelle de Genève*, *Société des Naturalistes de Genève*, and *Société des Sciences et des Arts du Département du Lot* and a correspondent of *Société Galvanique et d'Électricité de Paris*, *Sociétés Médicale et de Médicine Pratique de Montpellier*, *Société des Amateurs des Sciences de Lille*, and *Société d'Émulation de Lausanne*.

Besides the papers that he read before the Academy

[1] This paper, prepared at the invitation of the American Phytopathological Society, is an abridgment of the biographical sketch of Bénédict Prévost and the evaluation of his memoir on bunt published in: Prévost, Bénédict. 1939. Memoir on the immediate cause of bunt or smut of wheat, and of several other diseases of plants, and on preventives of bunt. Phytopathological Classics, No. 6. American Phytopathological Society, Menasha, Wisconsin. 95 p., pl. 1-3. Translated by George Wannamaker Keitt from: Prévost, Bénédict. 1807. Mémoire sur la cause immédiate de la carie ou charbon des blés, et de plusieurs autres maladies des plantes, et sur les préservatifs de la carie. Bernard, Paris. 80 p., pl. 1-3. (With a foreword, biographical sketch, and evaluation of the memoir by the translator.)

[2] Prévost, Pierre. 1820. Notice de la vie et des écrits d'Isaac-Bénédict Prévost. Paschoud, Genève. 110 p.

The following brief account of the life and works of Bénédict Prévost is drawn from this book by his cousin and life-long intimate friend and correspondent. Pierre Prévost's account is written with such authenticity, charm, and sympathetic understanding that it is abridged with as little change as possible, many passages being used in translation.

Abraham Prévost of Geneva, teacher ("principal du college") and pastor, had two sons. The older became a lawyer of distinction. Pierre, the younger, born in 1751, became a distinguished scholar in the fields of literature, philosophy, and the natural sciences. In 1780 he was appointed by Frederick II of Prussia to the Academy of Sciences at Berlin, where he also held a professorship in an academy for young gentlemen. Though he was highly successful in this work, his love and loyalty for his family and country were such that, in 1784, he accepted the chair of Belles-Lettres at the Academy of Geneva, though the stipend was hardly a third of that at Berlin. Here he completed his long and distinguished career. (Cherbuliez, A. 1839. Discours sur la vie et les travaux de feu Pierre Prévost, ancien Professeur de Philosophie à l'Académie de Genève. Ferd. Ramboz, Genève. 64 p.)

at Montauban, he published others through various scientific channels. Thus, by assiduous work, he laid the foundation of a solid reputation, gaining enjoyment from his discoveries and the continuous increase of his knowledge.

For him, the ardor for study did not at all interfere with the charms of friendship. The gentleness of his dealings, his amiable gaiety, the sureness of his character and his principles endeared him to all with whom he had associations. The very manner in which he had acquired his great knowledge contributed to its value. He was self-taught. Everything in his writings and his discourse was marked with the stamp of originality. He had invented what he learned; and, although long accustomed to draw from books instruction that he well knew how to appreciate, he always did this work in an active manner, meditating, repeating observations, varying experiments, judging his masters freely, and recognizing in the last resort nothing but his reason and nature.

Content to follow his tastes and the development of his interests in a quiet activity, Bénédict Prévost thought little of the avenue. But his friends thought for him. A protestant academy (*Faculté de Théologie protestante*) was founded at Montauban. There was needed a professor capable of filling with dignity the chair of philosophy. All eyes turned to Bénédict Prévost. The position was offered him, and after careful consideration he accepted it (in 1810). Thenceforth, he directed all his efforts towards the instruction with which he had been charged. He endeared himself to his students and was truly devoted to them. His courses were followed eagerly and fruitfully.

On June 10, 1819, at the age of 64, after a short illness, Bénédict Prévost died at Montauban in the home of M. Delmas. His death was universally regretted.

The works of this remarkable man are listed and discussed by Pierre Prévost (Loc. cit.). More than a score of papers were published in the following channels: *Annales de Chimie*, *Annales de Chimie et de Physique*, *Bibliothèque britannique*, *Bibliothèque universelle*, *Journal de Physique*, and *Annales de la Société pratique de Montpellier*. His unpublished works were still more extensive. The subjects that he treated covered a broad scope, including physics, chemistry, biology, and philosophy.

Bénédict Prévost's most important contribution is the memoir on bunt.[1] It is sad to record that this beautiful work, the crowning achievement of a life so singularly devoted to the advancement of knowledge, was denied fitting appreciation[3] during the lifetime of its author. Following the presentation of this paper at Montauban in 1807, the Society published it and sent it to the Institute, which appointed a Commission to examine it and make a report. M. Tessier, reporter for this Commission, "lauded the zeal, the acuteness, even the talent, of M. Bénédict Prévost in microscopic observations, but he did not at all recognize the strides of genius that he had taken along a course in which men of the highest merit had hitherto but groped."[4] This cold indifference, suffered from a body so well informed and justly celebrated, would have profoundly depressed a less modest man than Bénédict Prévost; but, far from protesting against this denial of justice, he made a law of silence, and imposed it, even to his last moments, upon his many friends. The preventive that he recommended, however, constantly safeguarded the crops of growers who used it with care. His memoir[5] penetrated into Belgium, England, and other countries, and foreigners profited by a discovery made in France, before the prejudices in favor of the old methods gave way. So it was that vaccination found apologists long after the discovery of vaccine.

A further discussion of the significance of the memoir is given in the following "evaluation."

AN EVALUATION OF THE MEMOIR ON BUNT[1]

In this memoir, Bénédict Prévost clearly showed that the immediate cause of bunt is a fungus. So far as the author is aware, this work contains the first recorded adequate experimental demonstration and interpretation of the role of a microorganism in the causation of a disease. It established one of the most fundamental and fruitful scientific concepts and laid a firm foundation for the later and more generalized germ theory of disease. The memoir contains many other contributions of outstanding merit, but this alone entitles it to recognition as one of the most significant pioneer works in the field of science.

Prévost's contribution bears critical examination. Founded upon able, painstaking experimentation over a ten-year period in the prime of his life, his essential findings stand unchanged. He gave a detailed and accurate description of the symptoms of bunt in the various macroscopic stages of its development. He noted the constant occurrence of "globules" in the bunted kernels and rightly suspected and proceeded to prove that they were the spores of a cryptogram. He described and illustrated these spores in detail and made extensive studies of their germination and the development of the "bunt plant" in relation to time, temperature, substrata, toxic agents, age and previous treatment of the spores, concentration of the spores,

[3] The following statements are drawn from an article quoted by Pierre Prévost (Loc. cit.) from *Journal du Tarn et Garonne*, July 21, 1819.

[4] All quotations in this sketch and the evaluation of the memoir are given in translation.

[5] Pierre Prévost (Loc. cit.) states that a very good abstract of the memoir appeared in *Recueil agronomique de la Société des Sciences de Tarn et Garonne*, September, 1820.

etc. Having concluded that he was dealing with a microscopic plant "of the genus of the uredos or a very nearly related genus," he proceeded by extensive and successful inoculation experiments to prove that it is the "immediate cause" of bunt and to define conditions that favor or hinder infection. He pointed out "that the vegetation of this plant, as well as that of the majority of the uredos, begins in the open air and is completed in the interior of the plant that it attacks," suggesting for such organisms "*the general denomination of internal parasitic plants.*" He observed germinated spores of the bunt organism in the soil and on the surface of wheat seedlings grown in infested soil. Though he did not succeed in observing the mode of penetration of the bunt fungus into the wheat plant or its growth to the wheat embryo, he correctly surmised that some ramifications of the bunt plant must penetrate into the very young wheat plant and later insinuate themselves into the embryo and fructify. He observed the fungus after it reached the wheat embryo and described its fructification there. He was unable to trace the details of the earlier stages in the formation of the bunt spores and had an erroneous idea regarding the development into spores of some of the smaller granules that he took to be their initials. He did, however, correctly recognize the more advanced young spores and found that they germinated typically. In extensive and refined toxicological studies, he found that certain copper salts, distilled water in which metallic copper had been left under suitable conditions, and various other substances in solution would prevent the germination of spores of the bunt fungus. He critically distinguished injurious and inhibitory from lethal effects and experimented extensively on relations of concentration of the toxic agent, time, and temperature to toxic effects. On the basis of the information thus obtained and of his extensive knowledge of the disease, he proceeded to experiment on the prevention of bunt. He made suitably controlled large-scale field tests in which inoculated seed wheat was planted after having received various treatments. Bunt spores from the treated seed were tested for germination, and data were taken on the development of the disease on the wheat grown in the field from the experimental seed. Excellent control of the disease was obtained by steeping the seed wheat in a copper sulphate solution, and detailed practical recommendations were made for performing this operation on a large scale.

In basic method and in interpretation, Prévost's work is surprisingly modern in the best sense of the word. Throughout his investigation he consistently used the best approach that has yet been found to the secrets of nature, the experimental method skillfully applied from the point of view of history of development. His work is remarkably comprehensive and well correlated and lays the foundation for nearly all major branches of modern plant pathology.

Prévost's more detailed techniques were in keeping with the quality and principles of his general plan. The methods that he developed for growing the bunt fungus in water culture, for example, were far ahead of his time. He controlled the quality of the water with reference to source, purity, and sterility; the quality of spores with regard to source, age, and previous treatment; and the conditions of the experiments with regard to such factors as temperature, moisture, availability of oxygen, quantity of spores and of water, and introduction of a wide variety of chemical compounds for study of their toxicity in terms of injurious, inhibitory, or lethal effects. He developed effective methods for minimizing contamination in the spore suspensions that he prepared for these experiments, using in part the principle of dilution. He clearly recognized the occurrence of contamination of cultures by air-borne spores or microorganisms and devised ingenious methods for its prevention. Here was laid an excellent foundation for the pure culture of microorganisms *in vitro*.

An example of Prévost's technical thoroughness and penetrating insight is found in his discussion of effects of "hard" water on the fungicidal action of dilute solutions of copper sulphate. He calls attention to the formation of a precipitate at the expense of the copper sulphate "in greater proportion as its (the copper sulphate's) quantity in relation to that of the water is reduced; so that, *if a very weak solution is filtered, the liquid that passes through does not produce nearly so great an effect.* . . . Does the precipitate act upon the bunt; or, indeed, *could the filter act upon the sulphate?* However it be, the precipitate and the solution in which it is suspended act, together or separately, upon all the bunt that the solution is capable of completely wetting." (The italics are added.) While he did not solve the problem of whether the filter acts upon copper sulphate, he clearly recognized and defined it. It is now easily demonstrated that the filter may retain most of the copper of a small quantity of dilute copper sulphate solution by adsorption. Many workers who followed Prévost in studies of the toxicity of copper fungicides failed to take this vitally important question into account. Much of the resulting confusion could have been avoided if his pioneer work had received the attention that it deserved. Furthermore, suitable studies of the fungicidal properties of Prévost's precipitate, which is closely related to the essential components of Bordeaux mixtures and their weathered residues, might well have hastened by many decades the discovery of fungicides of this type.

Prévost's interpretations are critical and discriminating and worthy of the quality of his experimentation. His conclusions are rigorously based on experimental proofs. In treating some questions concerning which the experimental evidence was incomplete, chiefly in relation to diseases that he necessarily studied less intensively than bunt, he justifiably uses analogy, some of which proved to be erroneous. When, however, he resorts to analogy, he does it frankly and deceives neither his reader nor himself regarding the basis of the reasoning. His work on other diseases was inci-

dental, and the quality of much of it is far below that of his essential contribution, the study on bunt.

His conception of parasitic disease is remarkably comprehensive and discriminating. He points out that the internal parasitic bunt plant is the immediate cause of the disease but makes it equally clear that the parasite can incite the disease only under sufficiently favorable conditions. In his title he refers to the bunt plant as the "immediate cause" of the disease, and in the text he usually speaks of it as the "immediate" or "direct" cause. Having clearly established the qualifications that attach to the causal role of the organism in relation to the disease, however, he does not hesitate in later passages to speak of the fungus as the "cause" of the disease. Prévost's usage deserves the careful consideration of those who are interested in clarity of concept and preciseness of terminology regarding these relations, which are so fundamental to general pathology.

A perusal of Prévost's memoir will reward one with many interesting by-products of his pioneering. His description of indirect germination of the "uredo with white dust" from Portulaca is probably, as he thought it to be, the first record of this type of germination. He gave a vivid and accurate description of what later became known, under a more generalized concept, as Brownian movement. Again, though his mention of the matter is incidental, his increasing knowledge of the development of microscopic plants and "animalcules" from pre-existing "gemmae," "spores," or "seeds" led him to express his disbelief in ideas of spontaneous generation that were then prevalent.

Prévost's ideas on the control of bunt are as clear and advanced as his conception of its nature, cause, and epidemiology. The ideal expressed in his closing sentence, . . . "to propagate pure seed, and to extirpate the germ of the infection from the soil of the Empire," should be a lasting inspiration to students of plant disease control. Even with all the splendid achievements of modern plant pathology, how far short we are of this ideal! Of course, there are many obstacles that Prévost could not foresee. But would he have been content to stop, even in the face of great difficulties, with methods that are in so many cases costly, laborious, and uncertain of success and that so often consist of an annually recurring protective program, with little or no attention to "extirpation" of the pathogen? May not some of the brightest chapters in the history of plant-disease control remain to be written on the basis of knowledge gained by pursuit of the ideals and application of the methods of this far-visioned pioneer? May not sufficient application of the experimental method to the study of the phenomena of plant disease from the point of view of detailed history of development reveal new possibilities for supplementing protective programs with such effectiveness that many destructive plant pathogens, even if they are not "extirpated from the soil of the Empire," can be reduced to such low levels of survival that they may be surely and economically controlled, or even eradicated locally or regionally? Surely one should give up such ideas "only when repeated and unsuccessful efforts force him to renounce all hope."

In failing to gain due recognition from his generation, Prévost but shared the common lot of pioneers in the advancement of knowledge. He was too far ahead of his time. The autogenetic theory of disease was dominant in places of authority. Who was this obscure tutor from the provinces that he should challenge the teachings of the Masters?

While it was not given the recognition that it deserved, Prévost's contribution was never entirely overlooked, and undoubtedly had an important influence on later work. It has already been stated that the memoir was reviewed in at least two popular journals[3, 5] and that the method of seed treatment became widely known through practice. The memoir also was cited in botanical literature. Of special importance is the extensive reference made to it by the Tulasnes,[6] with every evidence of confidence in the work and acceptance of its essential conclusions. Such treatment in a major publication by the leading mycologists of the time brought Prévost's work into conspicuous notice. Thereafter, he was widely cited, but chiefly for the germination of fungus spores and the discovery of the fungicidal action of copper sulphate. The full significance of his contribution continued to lack recognition, probably largely because of reliance of later workers upon reviews, the original being very rare.[7] DeBary,[8] for example, in the classical work that is correctly credited with establishing beyond further serious opposition the view that fungi are capable of inciting disease in plants, cites reviews and states that the original work was not available.

In contemplating the quality and significance of the work, one's thoughts revert to the man. It is then that his characterization by Pierre Prévost (p. 3), already notable for its intimate and sympathetic understanding, reveals a new depth of insight. Those who cherish the memory of men who have pioneered greatly in the advancement of knowledge and the amelioration of suffering may well pay a full measure of respect and admiration to this modest scholar of Montauban, who made such splendid "strides of genius along a course in which men of the highest merit had hitherto but groped."

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[6] Tulasne, L. R., and C. Tulasne. 1847. Mémoire sur les Ustilaginées comparées aux Urédinées. Ann. des. Sci. Nat., Ser. 3, 7: 12-127.

[7] To gain information regarding the availability in North America of Prévost's memoir and of the account of his life by Pierre Prévost (Loc. cit.), an inquiry was sent to more than 50 libraries that were thought to be the most likely to contain such works. Only one copy of each was located.

[8] Bary, A. de. 1853. Untersuchungen über die Brandpilze und die durch sie verursachten Krankheiten der Pflanzen mit Rücksicht auf das Getreide und andere Nutzpflanzen. G. W. F. Müller, Berlin. 144 p.

ABSTRACTS OF PAPERS ACCEPTED FOR PRESENTATION AT THE FORTY-SEVENTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY ATLANTA, GEORGIA, DECEMBER 27, 28, 29, 30, 1955

Embryo culture of tomato interspecific hybrids. ALEXANDER, LEONARD J. It has been shown previously that resistance to several diseases exists in plants of the species *Lycopersicon peruvianum*. One species cross by means of the embryo culture method was made previously by Smith. In this work, which was designed to obtain many such crosses, the following medium produced good embryo growth. The following, in mg/l, were added to White's mineral salt solution: sucrose, 20,000; malt extract, 15,000; glycine, 3.0; ascorbic acid, 20.0; thiamine, 0.15; riboflavin, 0.20; nicotinic acid, 1.0; calcium pantothenate, 1.0; vitamin B_{6}, 0.2; succinic acid, 25.0; and adenine, 20.0. The medium was solidified with 0.8 per cent agar. Twenty-seven crosses were secured in 1954, and approximately 50 more will be secured in 1955. The embryos were excised from the fruits 35–40 days after pollination. Approximately 30 per cent of the blossoms pollinated with pollen of *Lycopersicon peruvianum* developed into fruits when Break O'Day, Souix, or Cobourg were used as female parents. The variety Souix set slightly more fruit than did the others. Approximately 9 per cent of the fruits that set contained an average of 2.41 culturable embryos. Fruits of the variety Cobourg had the highest percentage of embryos.

Stem nematode of perennial forage legumes. ALLISON, J. LEWIS. Stem nematodes, *Ditylenchus* spp., are destructive to alfalfa in several locations but have not been observed damaging other perennial legumes in North Carolina. Thirty-one varieties and accessions of alfalfa and 2 varieties each of red and white clover, including Ladino, were tested in the seedling stage for susceptibility to 3 collections of alfalfa stem nematode obtained from widely separated areas of the state. Cotyledonary seedlings growing on moist blotting paper or in moist sand were inoculated by atomizing a suspension of nematodes onto them. Seedlings were kept moist and were incubated at 65° F. Initial symptoms appeared in 7–10 days, and reaction readings were made 2 weeks following inoculation. Surviving seedlings were grown to maturity. There were no differences in pathogenicity among the 3 collections. Differences in degree of susceptibility among the alfalfas and clovers were apparent. All alfalfas were more susceptible than the clovers. The stem nematode resistant alfalfa variety Lahanton and accessions derived from it exhibited only moderate resistance to the North Carolina collections.

Root knot of perennial forage legumes. ALLISON, J. LEWIS. Root-knot nematodes, *Meloidogyne* spp., are destructive to a large number of host plants and are known to attack the following perennial forage legumes in North Carolina: alfalfa, red clover, white clover (including Ladino), big and birdsfoot trefoil, and sericea lespedeza. Sixteen varieties and 5 accessions of alfalfa, 2 varieties each of red and white clover (including Ladino), 1 variety each of big and birdsfoot trefoil, and 5 accessions of sericea lespedeza were tested in both seedling and mature stages of growth to each of the 5 following *Meloidogyne* spp.: *M. arenaria, M. hapla, M. incognita, M. incognita acrita,* and *M. javanica.* Although plants of all legume genera were susceptible in both seedling and mature stages of growth, to each of the nematode species, they differed in degree of susceptibility. The clovers and trefoils were uniformly very susceptibile to all species. The alfalfas and sericea lespedezas were moderately susceptible to all species except *M. hapla.* To *M. hapla,* the alfalfas were very susceptible, but the sericea lespedezas were moderately resistant. Plants of a few alfalfa varieties and accessions were resistant to all the root-knot nematode species. There was greater variability in reaction in sericea lespedeza than in the other legume genera.

Plant disease control by a new class of chemicals, 2-pyridinethiol-1-oxide and derivatives. ALLISON, PATRICIA, AND G. L. BARNES. The chemical 2-pyridinethiol-1-oxide and 9 derivatives, representatives of a new chemical class called cyclic thiohydroxamic acids, were evaluated as foliage and soil fungicides and as nematocides. Because of promising results, the parent compound may become the prototype of a new class of plant disease control chemicals. ED_{50} values with conidia of *Monilinia fructicola* were between 0.03 and 0.4 ppm. ED_{95} values with the cucumber foliar anthracnose fungus were 11 to 60 ppm. ED_{95} values of nonmetallic derivatives with the tomato early blight fungus were 50–100 ppm. The copper and zinc derivatives and the water-soluble parent compound had high residual activity even when ½ in. of simulated "rain" was applied to treated tomato plants. Most of the compounds were noninjurious to foliage at concentrations well above ED_{95}. As soil fungicides, the majority of the compounds were similar to or better than pentachloronitrobenzene in controlling *Pellicularia filamentosa* or than captan (*N*-(trichloromethylthio) -4-cylohexene-1,2-dicarboximide) in controlling *Pythium ultimum.* None was injurious to pea seedlings, but some stunted cucumber and cotton.

Effects of ionizing radiations on the host-parasite relationship of stem rust of wheat. ANDERSON, ROGER V., AND HELEN HART. Urediospores of race 48 of *Puccinia graminis tritici* Erikss. & Henn. X-rayed at 15,000, 30,000, and 45,000 roentgens were inoculated on seedlings of Marquis, Mindum, Einkorn, and Khapli Emmer. Young mycelium in the host was X-rayed at 1000, 5000, 10,000, and 32,000 roentgens shortly after inoculation. Urediospores treated with thermal neutrons at a flux of 1×10^{10} neutrons/cm^2/second for 14, 28, and 56 minutes were used for the inoculation of seedlings of Reliance, Vernal, Lee, and Khapli Emmer. Number of uredia was inversely proportional to irradiation dosage, but no mutations in the rust were observed. Seeds of Marquis, Mindum, Einkorn, and Khapli Emmer were irradiated at a flux of 7×10^{10} neutrons/cm^2/second for 2, 4, and 6 minutes. The seedlings were inoculated in the field with race 48. The plants were stunted, and maturation was delayed by 2-minute exposure. Many sterile plants and early death occurred with 4- and 6-minute exposures. Recently, 24,000 seeds of Marquis, Kota, Mindum, and Khapli Emmer were exposed at a flux of 10^9 neutrons/cm^2/second, with gamma radiation eliminated, for 140 minutes. The seedlings were inoculated in the greenhouse. As yet, ionizing radiations have produced no detectable mutations in reaction of these wheats to race 48.

Protecting camellia grafts with fungicides. ANZALONE, LOUIS, JR., AND L. W. BAXTER. In camellia grafting, there is often a high mortality of scions. *Glomerella cingulata* is usually present on scions that fail to "take" or that die later. In tests during 1954, captan or ferbam, 3 lb./100 gal. were used as dips for scions and grafting tools. In 1955, the same 2 fungicides and also 4-4-50 Bordeaux mixture were used. In 1954, scions of the varieties Audusson, Ville de Nantes, Daikagura, Donkelarii, and Eleanor of Fairoaks, were used, and in 1955, scions of the varieties Audusson and Donkelarii. The Texas Star sasanqua was used as the root stock. The "take" for the 1954 treatment (average for the 5 varieties) was as follows: check, 80.5 per cent; captan, 97.0 per cent; and ferbam, 92.0 per cent. Striking differences were obtained with Ville de Nantes and Donkelarii varieties, which are difficult to graft. The percentage "take" (average for the 2 varieties) in these was

as follows: check, 60.1; ferbam, 94.2; and captan, 100. In the 1955 tests, the percentage "take" for Audusson was as follows: check, 82.0; ferbam, 63.9; captan, 92.1; and Bordeaux, 50.0. The percentage "take" for Donkelarii was as follows: check, 80.0; ferbam, 97.1; captan, 83.8; and Bordeaux, 50.0. Bordeaux toxicity is indicated.

Fungicides for control of dieback of camellias. ANZALONE, LOUIS, JR., AND A. G. PLAKIDAS. The demonstration by previous studies that infection by *Glomerella cingulata* occurs primarily through the scars of abscising leaves suggested control by fungicides. In laboratory screening tests with the glass-slide spore-germination technique, germination of conidia was completely inhibited by ferbam and captan, 1 ppm, and by Bordeaux at a concentration of 0.25–0.25–50 or higher. Bordeaux, 4–4–50, and captan, 3 lb./100 gal., were tested on camellia plants. In 1 series of tests, the leaves subtending lateral shoots were removed, the fungicide was applied and allowed to dry, then the plants were inoculated with a conidial suspension. The percentage infection (average of several replications on 4 varieties) was 81.9, 47.3, and 28.5 for check, captan, and Bordeaux, respectively. In another series, the fungicides were first applied and allowed to dry, then the leaves were removed and the plants were inoculated. The percentage infection (average of several replications) was 69.3, 34.5, and 16.2 for the check, captan, and Bordeaux, respectively. In both cases the plants were kept moist by subjecting them to natural or artificial rain for several days following inoculation. In all tests on plants, better protection was obtained with Bordeaux than with captan.

The role of fungi in the rapid deterioration of barley in storage. ARMOLIK, NEEME, J. G. DICKSON, AND A. D. DICKSON. The use of the combine harvester in humid areas has resulted in barley deterioration in storage on farms and in elevators at the malting plants. Fungi commonly associated with such barley were *Fusarium moniliforme*, 4 species of *Aspergillus*, and 2 of *Penicillium*. Experimental storage equipment was designed to study the influence of moisture, aeration, and fungi on deterioration of several types and varieties of barley. Storage without aeration at moisture contents of from 13 to 25 per cent resulted in loss of germination independent of fungi, in part because of the toxic effect of accumulated products of incomplete respiration. The growth of specific fungi in the grain resulted in rapid loss of germination, especially when the grain was aerated. The fungi differed widely in moisture requirements. Water extracts from the fungi and culture solutions of fungi grown on grain or synthetic media incited similar damage to barley embryos.

Nutritional deficiencies in some wilt Fusaria. ARMSTRONG, J. K., AND G. M. ARMSTRONG. Wilt-inducing Fusarium isolates have been obtained that do not grow in the synthetic mineral nutrient solution used in pathogenicity tests. Isolates from a cowpea plant grew when biotin was added; those from a sesame plant did not reduce calcium nitrate but grew when an ammonium salt was present. Numerous isolates from these plants, both mass and single spore, showed the same respective deficiencies. Apparently these variants existed in nature since they appeared as soon as the isolations were made. Reisolations from greenhouse plants inoculated with some of the isolates had the same nutritional requirements as the original cultures. Since each isolate was pathogenic on its respective host, these deficiencies were not linked with pathogenicity. Single-spore isolates from a culture of the sugar beet Fusarium grew sparsely in the solution. After growing on potato-dextrose agar, 1 of these and also 1 of the single-spore cultures from sesame produced a variant that required the addition of a natural extract to the solution. The factors responsible are undetermined. No additional nutritional variants have appeared in the cowpea cultures grown on potato-dextrose agar for 5 years.

Cultural, morphological, and pathogenic variability of Hendersonula toruloidea. ASHWORTH, L. J., AND E. E. WILSON. When isolated from the host and grown on potato-dextrose agar, *H. toruloidea* produces dark-colored conidia (arthrospores) by the segmentation of much-branched aerial hyphae. From such cultures was obtained a type that produced few conidia and large amounts of sterile, white aerial mycelium. Some of the single-spore isolates from this type were indistinguishable from it whereas others produced a type with few or no conidia and still larger amounts of sterile, white aerial mycelium. The latter type showed no further variation in culture. Over 90 per cent of the vegetative hyphal cells and conidia of the abundant-spored type contained 1 nucleus, the remaining 10 per cent never over 2 nuclei. Nuclei in vegetative hyphal cells of the sparse-spored type varied between 3 and 23. Vegetative cells of the sparse-spored type were much greater in length and diameter than those of the abundant-spored type. Inoculation experiments indicated that the sparse-spored type lacked the ability to produce typical cankers on Persian walnut branches.

The nature of the internal browning disease of tomato. BOYLE, JOHN S. For years the cause of internal browning, a ripening disorder of tomato, has not been understood nor the symptoms experimentally reproducible. Data and observations from field and greenhouse experiments beginning in 1951 reveal that 1) the disease may become endemic, 2) plants grown in endemic areas and inoculated with certain strains of tobacco mosaic virus soon after transplanting to the field do not produce internally browned fruits, 3) cuttings made from plants that have produced internally browned fruits once do not do so again even when planted in endemic areas, and 4) strains of tobacco mosaic virus originating from tomato plants that have produced internally browned fruits consistently cause the internal browning symptom when introduced into healthy plants as the fruits are beginning to ripen. Preliminary data show that restricted movement following inoculation leads to virus concentration in the fruits. The expression of internal browning symptoms is interpreted to be a "shock" reaction coming as a direct result of virus invasion and a hypersensitive response of the host.

The experimental reproduction of tomato internal browning by inoculations with a virus. BOYLE, JOHN S., AND DAVID C. WHARTON. Juice inoculations to *Nicotiana tabacum* var. Havana 38 and 423, *N. rustica*, *N. glutinosa*, *N. sylvestris*, and *N. plumbaginafolia* from hundreds of tomato plants expressing symptoms of internal browning consistently have yielded strains of tobacco mosaic virus. Representative isolates from tomato and weed hosts (horse nettle, plantain, Canadian thistle) growing near tomato fields where the disease is endemic have been used to inoculate Rutgers tomato plants in greenhouse and field experiments. The internal browning symptom consistently has been reproduced when the virus is introduced either hypodermically or by rubbing into healthy plants just as the fruits are beginning to ripen. Symptoms are expressed within 10–20 days when the peduncle of a ripening fruit hand is inoculated hypodermically. Symptom expression following inoculation by rubbing has been recorded within 18 days in the greenhouse. In the field, excellent expression of internal browning symptoms followed within 22 days mechanical inoculations with virus.

The role of saprophytic media in the development of southern blight and root rot on peanuts. BOYLE, LYTTON W. In greenhouse tests with peanuts, inocula of *Sclerotium rolfsii* and *Rhizoctonia* sp. were ineffective in sandy soil from which all organic matter had been sifted. After the addition of clean crop-refuse, such as leaves and stems of cotton, corn, or soybean, to the upper few inches of soil, these inocula were very effective. Dead plant tissues, such as crop refuse or dead tissues of otherwise live plants, served as bases of food without which these fungi were unable to attack the plant. The depth of such media in the soil, as it reflects a combination of temperature, aeration, and moisture, is a factor in the amount and severity of disease obtained. These inocula, when added with a

medium of soybean hay to the surface soil, were innocuous when the soil was covered by a plastic foil to reduce aeration. In greenhouse trials, soybean hay has been the most effective medium, with cotton and corn following in order. From the standpoint of disease control, methods of land preparation and weed control designed to keep organic material out of the upper level of soil are of much greater importance than the selection of crops in the rotation. In a limited number of field trials with cultural practices designed to apply this phenomenon, yields have been 3–4 times the average farm production.

Host relationship, morphology, and sporulation of Scolecotrichum graminis. BRAVERMAN, S. W. Timothy, tall oatgrass, and orchardgrass seedlings were inoculated with conidia collected from orchardgrass and timothy. Conidia from orchardgrass were pathogenic only to orchardgrass, and conidia from timothy infected only timothy. These data suggest the occurrence of physiological forms of *S. graminis* on orchardgrass and timothy. On the other hand, conidial measurements of isolates from the 3 hosts suggest no varietal distinction of the fungus. Isolates showed little variation in texture, color, and amount of mycelial growth. The optimum temperature for mycelial growth of the 3 forms was between 25° and 28° C. A method of inducing sporulation in culture by ultraviolet irradiation was developed. Conidia produced in the advancing mycelial zone 12 days after irradiation were morphologically similar to those found in nature.

Observations on secondary spread of Physoderma maydis on corn. BROYLES, JAMES W. Indications are that secondary spread of *Physoderma maydis* takes place by a spore form other than resting sporangia or zoospores liberated by them. Heretofore it was not thought to spread except by resting sporangia, although ephemeral sporangia have been reported. Liberation of resting sporangia begins 6 weeks after silking when plants are no longer susceptible; local secondary spread by this means seldom occurs. In sparsely infested fields, individual plants often are heavily infected (10,000–12,000 lesions), indicating spread on the plant. In a lightly infested field of 10,000 2-plant hills, each plant was classified as healthy or diseased and as in position 1 or position 2 in the hill. For each position, the ratio of diseased to healthy plants was calculated. These 2 numbers were multiplied together to obtain the probability of both plants being diseased. The difference between this figure and the actual proportion of such hills was used to calculate the percentage of diseased plants infected by spread within hills (10.3 per cent). Diseased plants also were counted in rows each of which was bordered by inoculated rows having different levels of infestation. Little infection occurred on plants adjoining disease-free rows, 70 per cent were infected adjoining moderately infested rows, and 100 per cent adjoining heavily infested rows. Noninoculated suckers in inoculated rows usually were infected.

Observations on time and location of penetration in relation to amount of damage and chemical control of Physoderma maydis. BROYLES, JAMES W. *Physoderma maydis* infects corn at any stage from seedling to silking. Location of lesions and amount of damage depend on the time of infection. Damage was greatest in plants inoculated when 35 to 45 days old. Single inoculations at 39 days resulted in 100 per cent lodging; at 32 and 53 days there was 50–80 per cent infection but little lodging. Infections at 25 days or earlier caused more leaf lesions but fewer infected plants and less damage. Most infection apparently takes place in meristematic tissue in the leaf whirl, which makes complete chemical control possible, although no effective control has been reported previously. In noninoculated plots containing many natural infections and in plots in which plants were inoculated 6–12 times, spraying in the leaf whirl twice a week for 4 weeks before silking gave almost complete control. Fewer applications also greatly reduced infection and lodging. Crag 341 (34 per cent glyodin), Phygon-XL (50 per cent dichlone), and Tenn. Corp. Copper-Zinc (basic copper sulfate, zinc sulfate; 26 per cent Cu, 8 per cent Zn) were toxic to corn, whereas Orthocide 406 (50 per cent captan) and Fermate (76 per cent ferbam) were nontoxic. All gave good control, however. These controls are being used along with new inoculation techniques in basic studies on the disease to determine losses and to test for resistance. They may eventually be used to control brown spot in seed and field corn.

Resistance to anthracnose in cucumber. BUSCH, L. V., AND J. C. WALKER. Of some 130 foreign introductions of cucumber tested for resistance to *Colletotrichum lagenarium*, 8 were worthy of further consideration. Results obtained from F_2 and backcross progenies, when Accessions 163213, 163217, and 175111 were used as male parents and variety SMR12 as the female parent, suggested that resistance was of 2 distinct types, multiple and single factor. A histopathological investigation revealed that appressorial formation started approximately 10 hours after inoculation, followed by direct penetration some 58 hours later. Colonization was intracellular, and the mycelium had a definite affinity for the small veins in the leaf. The early stages of infection were identical in both the resistant and susceptible hosts. As infection progressed in the susceptible host, the mycelium spread rapidly throughout the leaf, followed by protoplasmic disintegration and tissue collapse. In the resistant host there was little cell collapse, and protoplasmic disintegration was never more than 1 or 2 cells in advance of the hyphae. An apparent thickening of the cell wall in definite areas and the deposition of globules of red staining gum-like material frequently accompanied the resistant reaction.

Seed perpetuation of lignocortosis (wood pocket) of semidense Lisbon lemon. CALAVAN, E. C. All known symptoms of lignocortosis, except fruit striping, appeared in seedlings from diseased semidense Lisbon lemons. Variegation developed early in 0 to 22.5 per cent of the seedlings from 36 diseased sources. Slightly diseased parents gave 3 per cent and severely diseased ones 17 per cent variegated seedlings. Dark splotches occurred on shoots of some seedlings within 3 years. Cankers associated with V-shaped necrotic sectors in the branches and stems of seedlings 4–6 years old caused dieback and killed seedlings. No lignocortosis symptoms developed in 9331 citrus seedlings, including lemons other than semidense Lisbon, from 3 parent groups: those topworked on diseased interstocks for 4 years, those that carried buds from diseased trees for 7 years, and those grown as controls. Lignocortosis symptoms occurred in the roots of diseased semidense Lisbon seedlings but not in other rootstocks or interstocks under diseased lemon or seedless lime tops. The erratic occurrence of leaf, root, and shoot patterns and of necrotic streaks and sectors in the bark, wood, and fruit peel of diseased trees, together with the failure of diseased tissue grafts to produce symptoms in healthy trees or in seedlings therefrom, suggests the probable unstable chimeral nature of lignocortosis.

Wetting and penetrating agents combined with fungicides as protectants and eradicants for wheat stem rust. CAMPOS, ALFREDO, AND N. E. BORLAUG. Sulphur dust (10 micron) was suspended in solutions of chemicals used in the textile industry as wetting and penetrating agents and carriers of dyes. Wheat seedlings were sprayed before and after inoculation with urediospores of *Puccinia graminis* var. *tritici*. Sprays applied 24 hours prior to inoculation were washed off the foliage with tap water (5 lb. pressure spray) immediately before inoculation. Twenty days later, only 3 to 5 uredia had developed on 40 plants treated with wettable sulphur suspended in solutions of wetting and penetrating agents of the sulfonated or sulfated types such as Monosulph, Penequick, or Soromine; 500 uredia had developed on 40 nontreated plants. Protection apparently was due to penetration and retention of the chemicals in the fine interstices of the leaf surface. Sprays applied to seedlings 3 days after inoculation did not reduce infection.

Since acid solutions are better penetrants than neutral or basic solutions, certain acids were used in combination with Victawet 12 as wheat foliage sprays 6 days after inoculation. Sulfamic acid inhibited further sporulation for 10 days, but within 30 days the mycelium was again sporulating normally. Sulfanilic acid strongly inhibited further rust development and uredia were observed only occasionally after 30 days.

Effect of a by-product of Cephalosporium gregatum on water flow in soybean stems. CHAMBERLAIN, DONALD W. Experiments were made to detemine whether the reduction in water flow in the vessels of soybean stems infected with *Cephalosporium gregatum* can be attributed to a by-product of the fungus. The brown pith and some of the vascular elements were scraped from the stems of infected plants. Twenty-five g of the scrapings were blended in 250 ml distilled water in a Waring blender, and the resulting mixture was centrifuged. The tests were made on 7-cm sections of healthy soybean stems. The normal rate of water flow was determined by measuring the amount of distilled water forced through a stem section in 4 minutes under pressure (15 lb./sq. in.). The extract was then forced through the stem section in like manner, after which the rate of flow was again determined with distilled water. Water conduction was reduced 65–80 per cent after the extract had passed through the vessels. The principle involved in reducing water flow in the vessels was not removed by passage through a Seitz filter, nor was it inactivated by autoclaving for 20 minutes at 15 lb. pressure. Diluting the extract 1–10 had no appreciable effect. Extracts made from agar cultures of the fungus had an effect similar to that of extract from diseased stems. The extract caused internal browning, but not wilting, in seedling plants.

Incidence of tristeza virus in Florida in trees not yet showing field symptoms. COHEN, MORTIMER. A survey has been made throughout the citrus growing areas of Florida to determine the incidence of tristeza virus in trees on sour orange rootstock that appear healthy. At each of the 25 locations chosen, 8 trees were sampled near a tree known to be in decline with tristeza disease. Both histological and transmission tests were used to determine the presence of the virus. The highest proportion of infected symptomless trees was found in the Orange-Lake county area, which is considered to be the area of most rapid spread of this disease. This pattern of distribution of tristeza virus is confirmed by another study in which citrus trees on various rootstocks and located throughout Florida were indexed on key lime seedlings. Some trees on sour orange rootstock show neither field nor histological symptoms, although it has been more than a year since they were found to be infected with tristeza virus. This study will help provide precise information on the interval between initial infection of mature citrus trees and their eventual decline. Continued studies of this nature may prove of value in predicting future extensive outbreaks of tristeza.

Correlation of antimicrobial activity and chemical structure of certain aromatic ketones. COHEN, SYLVAN I., AND MARTIN S. FRANT. During the course of a screening program, the biological activities of approximately 35 related aromatic ketones were determined by 1) agar-plate assay against *Asperigillus niger;* 2) bactericidal concentration counts with *Aerobacter aerogenes;* and 3) spore-inhibition tests with *Sclerotinia fructicola* and *Stemphylium scarcinaeforme.* Derivatives of acetophenone were prepared and tested for biological activity. Introduction of a hydroxyl group in the para position markedly increased activity. Further hydroxylation of the ring decreased activity, as did substitution of a *p*-amino group. Major enhancement resulted from the replacement of the methyl group by C=C to form alpha and beta unsaturated ketones. Adding cyclic structures (benzal, furfural) to the terminal CH_3 of these ketones reduced activity. Adding COOH to the terminal CH_3 group to form β-benzoylacrylates produced additional increases in activity. Further enhancement resulted from the formation of lower alkyl esters. For the most effective structure, methyl benzoylacrylate, the decreasing order of effectiveness for para-substituents was Cl > none > CH_3 > Br > OH. The bactericidal order was slightly different, indicating specificity of these compounds.

The production and germination of conidia of Cladosporium effusum in the laboratory. CONVERSE, RICHARD H. Single spore cultures of *C. effusum* grew well but sporulated poorly or not at all on agar media made from potatoes, lima beans, corn, prunes, carrots, V-8 juice, or pecan-leaf pieces. No sporulation occurred on media composed of agar, ammonium nitrate, salts, and 1 of a number of carbon sources. The addition of B vitamins did not improve sporulation. Oatmeal and particularly Chinese chestnut agar allowed abundant conidial production. Of 45 isolates grown on oatmeal agar, only 8 sporulated abundantly, whereas 12 were sterile. The cardinal temperatures for spore germination were as follows: maximum, 40°; optimum, 25°; and minimum, <0°C. Germination was rapid in distilled water at 24°C, 34 per cent of maximum germination occurring in 4 hours and 77 per cent in 6 hours. Conidia held at 24°C in 100 per cent relative humidity (R.H.) had a germination level that was 14 per cent of that of distilled water controls after 4 hours and 69 per cent after 24 hours. The comparable figures were 4 per cent and 51 per cent at 99.8 per cent R.H. Germination was zero at and below 90.1 per cent R.H. Conidial germination in the absence of free water may explain the increase in scab lesions observed on pecans after rainless periods. Night temperatures and R.H. values measured before such increases were suitable for germination of conidia.

Further evidence of the value of eradicant fungicides for control of pecan scab. CONVERSE, RICHARD H. Phenyl mercury compounds, sodium pentachlorophenate (PCP), and monocalcium meta arsenite (MMA) were effective in 1 or both of the following small-scale trials: 1) a laboratory test of toxicity to pure cultures of *Cladosporium effusum* (Wint.) Demaree grown on agar, and 2) a field test in which scabbed overwintered pecan nut shucks were sprayed and suspended in containers above nonemerged pecan shoots. In the latter test, incidence of lesions on young foliage was used to assess eradicant action. Phenylmercuritriethanol ammonium lactate (PML), PCP, and MMA were then used in field tests in 1955. Conidial production on overwintered lesions following 2 eradicant sprays in March of trees and of the ground beneath them was reduced by May to 0–3 per cent of the levels in the unsprayed controls. By August, unsprayed nuts averaged 88.7 lesions per shuck. Trees given 2 MMA sprays averaged 5.9 lesions per shuck, and trees given 4 ziram protectant sprays averaged 2.5. Nuts from trees sprayed with ziram and PML averaged 0.9 lesions; those with ziram and MMA, 0.6; those with ziram and PCP, 0.3; and those with ziram and MMA (where, in addition, the surrounding ground was sprayed with MMA), 0.01. No phytotoxicity was observed on the trees after use of any eradicant.

Chemical control of Sclerotium rolfsii in peanuts. COOPER, W. E. Peanut losses due to Southern stem rot (caused by *Sclerotium rolfsii* Sacc.) have been reduced by modified cultural practices, yet sporadic destructive outbreaks of the disease still occur. Thus, an effective fungicidal treatment applied when the epiphytotic first becomes evident would prevent these disastrous losses. To test this possibility, chemicals were applied as drenches at 900 gal./acre to previously inoculated peanuts. Three chemicals, pentachloronitrobenzene (PCNB), captan, and thiram, gave promising results at 6 and 12 lb./acre. At 12 lb./acre, they reduced the number of dead stems 53, 36, and 47 per cent, respectively, and increased the yield of pods 73, 21, and 14 per cent, respectively. In a more extensive test, the 3 materials at 12 lb./acre reduced the dead stems by 71, 55, and 51 per cent, respectively. The following 6 chemicals were ineffective: zineb at 10.4 and 20.8 lb./acre, dichlone

at 4 and 8 lb./acre, cuprous oxide at 16 and 32 lb./acre, phenylamino cadmium dilactate at 1.6 and 3.2 lb./acre, 3-5-dimethyltetrahydro-1,3,5,2*H*-thiadiazine-2-thione at 7.6 and 15.2 lb./acre, and chlorobromopropene at 2.2 and 4.4 lb./acre.

Control of downy mildew of lettuce. Cox, R. S. Production of high-quality lettuce in the Florida Everglades is dependent upon control of downy mildew, caused by *Bremia lactucae* Regel. An adequate control recommendation was lacking. In 7 x 7 Latin square field plots, fungicides were applied twice weekly, chloranil and basic copper sulfate at 4-100, and all others at 3-100. Ratings of disease severity (0-11), vigor (0-11), and yield (marketable heads), respectively, were as follows: check, 7.6, 6.0, and 27; zineb (zinc ethylenebis[dithiocarbamate]), 2.1, 9.3, and 36; ferbam (ferric dimethyldithiocarbamate), 3.3, 9.0, and 34; captan (*N*-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide), 3.4, 7.7, and 33; basic copper sulfate, 3.1, 5.4, and 27; chloranil (tetrachloro-*p*-benzoquinone), 3.9, 4.9, and 26; pentachloronitrobenzene, 7.6, 3.1, and 11. Vigor ratings reflect both disease severity and phytotoxicity. The correlation coefficient between disease severity and yield was —0.63 (not significant), and between plant vigor and yield, 0.93 (highly significant). The LSD for yields at 0.05 was 6; at 0.01, 8.

Observations on the occurrence of soybean stem canker. Crall, J. M. Studies on Diaporthe stem canker of soybean were made in Iowa during the period 1948–1952. Infections occurred on both blade and petiolar portions of leaves, and the usual means of entry of the stem canker fungus was at the base of petioles, not through leaf scars or stem wounds as reported by other workers. Perithecia and mature ascospores were found infrequently on infected plants, providing possible means of secondary spread of the disease. Average daily mean temperatures below 70°F favored the development of stem canker in the field, whereas 60°F was optimum in greenhouse tests. A highly significant regression coefficient (—0.268 bushels per acre per unit percentage infection) was determined for the effect of stem canker on soybean yields. The regression of stem canker infection on plant maturity was positive and highly significant. The regression of infection on lodging was negative and highly significant. The latter probably accounts for the extreme susceptibility of the lodging-resistant varieties Hawkesbury and Blackhawk that has been reported by some workers.

Watermelon fruit rot caused by Mycosphaerella citrullina. Crall, J. M., and Phares Decker. In 1954, the imperfect stage of *Mycosphaerella citrullina* was identified from a restricted lesion on a single fruit of the variety Charleston Gray. In 1955, several occurrences of a fruit rot caused by the fungus were noted in Florida on this same variety. Rejection of carload shipments both at shipping points and terminal markets resulted apparently from this disease. Lesions were browned and more or less circular, often with prominent pycnidia. They occurred at various places on the melon. Individual lesions were superficial at first, but they developed up to 3 in. in diameter and into the internal tissues of the melon. When melons were stored in a dry room, lesion development was restricted, but at higher humidities, secondary organisms frequently invaded, and rot development was rapid. Fruit rot developed on melons of the varieties Charleston Gray and Fairfax after inoculation with wounding, but not on unwounded melons. In its early stages and in sporulation, infection after inoculation was typical of that occurring naturally. Natural infection of melons has not been noted on varieties other than Charleston Gray.

The influence of pH, buffer, and temperature of the wash medium on the amount of infection by tobacco mosaic virus on Scotia bean leaves. Dale, J. L., and H. H. Thornberry. Scotia bean leaves inoculated with tobacco mosaic virus at pH 8.5 in 0.1 M phosphate buffer were washed immediately by dipping the inoculated leaves for different periods of time in distilled water or in 0.1 M phosphate buffers at various pH values and temperatures. No essential difference was detected between the use of sodium or potassium phosphate buffers for the wash. The amount of infection after washing in buffer at pH 8.5 was only slightly reduced by increases in duration of washing up to 1 minute. When a pH 5.5 buffer was used, the amount of infection was markedly reduced by increases in duration of washing, as was the case with distilled water wash. The number of local infections following washing for 1 minute with buffers varying in pH was low at pH 3.7 and 5.5, higher at pH 3.0, and higher still at pH 8.5 and 9.5. That following washing in water at temperatures from 5° to 45°C was reduced with an increase in temperature.

Black root of sugar beets as influenced by various cropping sequences and their associated mycofloras. Deems, R. E., and H. C. Young. The soil mycofloras associated with croppings of alfalfa, corn, oats, sugar beets, and a bluegrass-ryegrass mixture, which were growing in soil previously cropped to sugar beets for 2 seasons, were measured qualitatively and quantitatively by the dilution-plate method. The soils were sampled monthly following planting to the various crops. Black-root pathogens were assayed in these soils by planting untreated sugar beet seeds and recording the incidence of disease. The percentages of black-rooted seedlings in soil sampled May 6 and August 7, respectively, follow: sugar beets, 100 and 94.9; alfalfa, 100 and 87.5; ryegrass-bluegrass mixture, 84.3 and 37.5; oats, 92.2 and 25.0; and corn, 84.3 and 10.3. A significant reduction of black-root occurred in soils previously cropped to corn and oats, as shown by the difference between the May and August readings. *Aphanomyces cochlioides* was isolated from 87.9 per cent of all black-rooted seedlings. The mycofloras associated with these crops varied little during the growing season, but some quantitative differences occurred. *Aspergillus fumigatus, Trichoderma viride,* and some species of *Penicillium* were significantly more prevalent in corn and oat soils than in alfalfa and sugar beet soils.

Comparison of fungicide and fungicide-insecticide seed treatments of peas and beans. deZeeuw, Donald J., Axel L. Andersen, and Gordon E. Guyer. Three years' trials on Alderman peas and Round Pod Kidney Wax beans in Michigan showed that several seed-treatment fungicides were consistently superior. When results were averaged, the order of effectiveness on peas was the following: Orthocide 75 (75 per cent captan), Phygon S.P. (50 per cent dichlone), Merculine (10 per cent phenylmercury salicylate), Ortho Seed Guard (25 per cent captan; 25 per cent lindane), Arasan SF-X (75 per cent thiram), and DuPont I & D (56 per cent thiram; 14 per cent lindane) or Delsan A-D (60 per cent thiram; 15 per cent dieldrin). In 1953, 22 of 29 materials were statistically superior to the control; in 1954, 25 of 39; and in 1955, 29 of 34. There were also many significant differences within the groups. In the case of peas, the addition of an insecticide to the fungicide gave no benefits and reduced emergence slightly in the absence of insect infestation. When results were averaged, the order of superiority on beans was Ortho Seed Guard, DuPont I & D, Merculine, Orthocide 75, Semesan (30 per cent 2-chloro-4-(hydroxymercuri)phenol), Setrete (7 per cent phenyl mercury acetate), Puraseed (6.25 per cent anilinocadmium lactate, 6.25 per cent *N*-phenylmercuriformamide), Arasan SF-X, and Phygon S.P. In 1953, 21 of 29; in 1954, 33 of 39; and in 1955, 37 of 43 materials gave statistically superior stands. Significant differences existed in each case within the group giving effective protection.

Clones of Kenland red clover as local-lesion hosts for yellow bean mosaic virus. Diachun, Stephen, and Lawrence Henson. Several clones that produce necrotic local lesions when rubbed with yellow bean mosaic virus have been selected from populations of Kenland red clover. Dark circular or angular necrotic spots form on rubbed

leaves in 4–6 days under greenhouse conditions. The virus does not always remain confined in the local lesions; some plants become systemically necrotic and die. Differences occur among clones in the number of local lesions that develop, in the number of plants that become systemically necrotic, and in the time between inoculation and systemic invasion.

Progress reports on genetics of pathogenicity of Puccinia sorghi. DICKSON, J. G., P. M. LEROUX, R. SYAMANANDA, AND A. L. FLANGAS. Eight single dominant factor pairs that condition resistance to rust and are inherited independently have been isolated from corn of North and South American origin. Seven races of *Puccinia sorghi* that are specific in pathogenicity (virulence) for 7 of these factors have been isolated and pure-lined. The Cuzco factor has conditioned resistance to all isolates tested. Each factor pair is being transferred separately into a common homozygous susceptible line to study the nature of resistance. Inbreeding uredial clones of *P. sorghi* and *P. purpurea* through the aecial host, Oxalis, has resulted in stable uredial clones differing in range of pathogenicity from the originals; i.e. uredial clones of *P. sorghi* that incite rust on *Sorghum* spp. and of *P. purpurea* that incite rust on corn. Apparently, inbreeding has resulted in reassortment of factors for pathogenicity that were not expressed or were in a recessive condition in the original dicaryon clones.

Sapwood formation and infection by the oak wilt fungus. DRAKE, C. R., J. E. KUNTZ, AND A. J. RIKER. Each week from April 20 through September 10, 1955, 50 different northern pin oaks were variously wounded, and 45 were inoculated through lateral branches or root collars. At budbreak (May 1), springwood vessels were initiated. Inoculated trees that wilted in September, 1954, also resumed cambial activity, but died when the fungus invaded the 1955 vessels (June 8). Prior to May 1, wounding induced tylosis formation in the 1953 and 1954 annual rings. Later, and uniformly through July, wounding induced rapid plugging mostly in the 1955 springwood vessels to a height of 5 ft. above the wound. Thereafter, plugging was less extensive. Wound tyloses formed most rapidly in fully exposed trees. "T" wounds and ax cuts permitted many natural infections, especially during springwood development. All inoculated trees leaved normally. Trees inoculated through May 28 showed incipient wilt on June 14. Inoculations after leaf expansion (June 1) induced symptoms uniformly within 2–3 weeks. Inoculations made prior to summerwood formation (June 17) gave numerous infections; thereafter, few infections. Branch inoculations through either 1953, 1954, or 1955 sapwood gave comparable infections. High temperatures limited infections.

Further studies on the taxonomy, identity, and host range of the dwarf bunt fungus. DURAN, RUBEN, AND GEORGE W. FISCHER. Critical study of hundreds of herbarium specimens adds the following records to the dwarf bunt complex (original determination in parentheses): *Aegilops umbellata*, Turkey (*Tilletia tritici*); *Bromus erectus*, Czechoslovakia (*T. guyotiana*); *Elymus crinitus*, Yugoslavia (*T. bornmülleri*); *Hordeum bulbosum*, Syria, Russia, Turkestan, Turkey, Yugoslavia (*T. hordei, T. pancicii, T. brevifaciens*); *H. leporinum*, Iran, Australia, Algeria, Turkey, Spain (*T. caries, T. hordei*); *H. vulgare*, Bulgaria, Japan, Yugoslavia, Iran, Iraq (*T. hordei, T. pancicii* (type)); *Lolium remotum*, Denmark (*T. lolii*); and *Secale cereale*, Roumania, Czechoslovakia, Switzerland, Turkey (*T. secalis, T. tritici, Ustilago*). The type of *T. pancicii* definitely belongs in the dwarf bunt complex, but the types definitely exclude *T. bornmülleri* and *T. lolii*. *T. hordei* probably is included, but the type is not yet available. Three apparently different rye smut fungi are in herbaria under *T. secalis*: a bunt fungus agreeing well with the dwarf bunt fungus of wheat and other hosts, the common bunt fungus (*T. caries*), and a bunt fungus that does not fit either of these. What the real *T. secalis* is can be determined only from the type of *Uredo secalis* Cda., not yet available. Should this be included, then *T. secalis* would become the valid binomial by earlier priority. At present, *T. contraversa* still has priority.

Root abnormalities caused by burrowing nematode infections. FEDER, WILLIAM A., AND JULIUS FELDMESSER. *Radopholus similis*, the burrowing nematode, frequently causes symptoms on grapefruit seedling roots similar to those usually ascribed to nematodes such as *Meloidogyne* spp. Grapefruit seedlings were grown in soil infested with *R. similis*. After 9 months, the plants were badly stunted and chlorotic, and the roots were reduced greatly in number and extent, were covered with lesions, and were distorted. Root tips were swollen, spatulate or football-shaped; large elongate or round swellings were present along the entire lengths of some roots, giving them a beaded appearance. Lateral rooting (bearding) often occurred on the sides of swellings distal to the root crown. Lesions of various sizes covered all the roots and rootlets and were present in the crown. Some lesions coalesced to form large cankers with callused margins. Younger lesions were slightly discolored and crumbly, whereas older lesions were brown and crumbly. Cankers had dark centers and firm brown margins. Upon dissection, lesions and swollen areas alike yielded large numbers of all stages of *R. similis*. No other plant-parasitic nematode was present. Externally, these swellings appear similar to those described on Heterodera-infected tomato roots, Xiphinema-infected rose roots, and the roots of many plants infected with Meloidogyne.

The occurrence of Pratylenchus spp. in Florida soils. FELDMESSER, JULIUS, WILLIAM A. FEDER, AND J. A. PINCKARD. *Pratylenchus* spp. were recovered from over 95 per cent of 215 collections of roots and soil from both agricultural and nonagricultural areas in Florida since May 1954. The collections were made in central and south Florida, ranging from Gainesville to Homestead, and included samples from the sandy ridge soils and from the marl and muck areas in the east and south. Hosts include citrus, avocado, banana, castor bean, tobacco, tomato, 3 grasses, a number of weeds, and 22 commercially important ornamentals. The following species of *Pratylenchus* were recovered: *P. pratensis, P. brachyurus, P. minyus, P. zeae*, and *P. scribneri*. The species most commonly observed was *P. brachyurus*. These data indicate that *Pratylenchus* spp. are native to Florida, are wide-spread in the state, and may be important parasites of commercially valuable Florida crops. This information, together with that obtained by federal workers in Georgia and by state agencies in North Carolina and Kentucky, suggests the importance of this genus in the South.

Black root of strawberry seedlings grown aseptically. FELIX, E. L. A black root disease has been observed on young seedlings of wild strawberry, *Fragaria virginiana*, grown on potato-dextrose agar of pH 5.9–6.0 from Cl-treated seeds collected near Knoxville, Tenn. Affected primary and secondary roots were first brown and then black; root hairs in general remained hyaline, although some brownish wall swellings of uncertain origin were noted. An unidentified chytrid, presumably seed borne, appears to be constantly associated with this type of black root and is thought to be the causal agent. Sporangia, swarm spores, and oospores occurred and are being studied further. Healthy roots appeared to be free of the fungus.

The effect of soil temperature on the life cycle of the golden nematode. FERRIS, J. M. The effect of temperature on the life cycle of *Heterodera rostochiensis* in several Solanaceous plant species has been studied. Temperatures used were 65°, 75°, and 85°F. One nonhost, *Solanum citrullifolium*, and 2 hosts, *S. dulcamara* and *S. tuberosum*, were used. Seedlings of these plants were grown in glazed crocks filled with soil infested with the golden nematode. The soil was kept at the desired temperatures by placing the crocks in tanks constructed from stock-item milk coolers. Plants were harvested at intervals, and the roots were washed free of soil, then killed and fixed in formalin-

aceto-alcohol. Nematodes in the roots were stained with acid fuchsin in lactophenol. Examination showed that second-stage infective larvae enter both host and nonhost plants at all 3 temperatures. The larvae do not develop further in the host plants kept at 85°F. This reaction appears similar to that which occurs in the nonhost *S. citrullifolium* at all temperatures. In the host plants *S. dulcamara* and *S. tuberosum*, the most rapid development of the nematode occurs at 65°F.

Electron microscopy of golden nematode cyst wall. Ferris, Virginia Rogers. Ultrathin sections of the wall of mature golden nematode cysts have been examined with the electron microscope. The cysts were fixed in a 1 per cent solution of osmium tetroxide, dehydrated by an alcohol series, and embedded in a mixture of butyl and methyl methacrylate. Electron micrographs show the 2 principal layers that can be seen in thicker sections with the light microscope. The 2 layers are separated by a well-defined line of demarcation. There are no sharp divisions within the outer layer, the exo-cuticle. No evidence was obtained for the presence of fibrils such as those described by Wieser from light-microscope observations of the faint radial striations visible in this layer. Five distinct layers can be distinguished in the inner layer, the endo-cuticle. A layer that is probably the basal lamella also is discernible.

Some new records of dwarf bunt of wheat and rye. Fischer, George W., and Ruben Duran. Insofar as can be determined from an abundance of herbarium material from all over the world, the following new records of early incidence and/or geographic distribution have been established for dwarf bunt of wheat and rye. Wheat: U.S.A.—Herkimer Co., N. Y., *ca.* 1890; Batavia, N. Y., 1920; Seneca Co., N. Y., 1923; New Carlisle, Ind., 1917; Wayne Co., Utah, 1918; Jacksonville, Calif., 1917; Rockland, Idaho, 1918; La Grande and Pendleton, Ore., 1921. Czechoslovakia — (locality unknown), 1847. Germany — (locality unknown), 1890; Schweidnitz, 1891. Austria — Salsburg, 1884. West Persia—Sultanabad, 1908. Yugoslavia—Belgrade, 1949. Rye: Czechoslovakia—Schoenberg, 1891. U.S.A. —Syracuse, N. Y., 1892. These collections had been determined originally as various species of *Tilletia*, *Ustilago*, and *Uredo*. Thus dwarf bunt of wheat occurred in Europe as early as the middle of the last century and probably earlier, and in the United States at least as early as 1890.

Modifications in soils of southern pine nurseries produced by fungicidal and nematocidal chemicals. Foster, A. A., E. F. Cairns, and Bruce Hopper. Fumigation of nursery soil in which pine seedlings developed severe root rot symptoms increased the number of marketable slash pine seedlings from 35 per cent to 100 per cent. Methyl bromide proved more effective than ethylene dibromide or D-D (1,3-dichloropropene; 1,2-dichloropropane). Although nematocides reduced the severity of black root symptoms, a combination of a nematocide and a fungicide was more effective. Present indications are that root symptoms are the result of attack by a nematode-fungus complex. Soil chemical treatments did not prevent development of normal mycorrhizal roots on pine seedlings. Modifications of the soil flora and fauna were also investigated.

Yearly variations in amount of virus in Arkansas strawberry fields. Fulton, J. P. Of strawberry plants collected at random from commercial plantings in 1949 and 1950 and indexed for virus, less than 5 per cent were virus-free. In similar collections made in 1953 and 1954, virus-free plants were encountered much more frequently, with the result that more than 25 per cent of the plants tested were virus-free. In 1954, 2 plantings made from virus-infected clones yielded virus-free plants after a single season in the field. This suggests that during warm seasons the viruses remain localized to the extent that virus-free runner plants may be produced.

Comparative herbaceous host ranges of two prunus viruses. Fulton, Robert W. The objects in testing herbaceous species for susceptibility to mechanical inoculation were 1) to determine whether differential hosts could be used to separate and identify Prunus viruses, and 2) to find local-lesion hosts for quantitative studies. One virus (A), carried in cucumber, was originally obtained from sour cherry with recurrent necrotic ringspot. The other virus (B) was isolated from a sour cherry with yellows, as reported by Varney and Moore, and carried in tobacco. Inoculum was prepared by grinding in 0.05 M phosphate buffer (pH 7 or 8) young leaves of these hosts within a few days after systemic symptoms first appeared. Over 150 species were inoculated. Virus A infected 16 species in 3 families (Cucurbitaceae, Leguminosae, Solanaceae), symptoms being produced only on the cucurbits. Virus B infected 53 species in these 3 and 7 other families (Acanthaceae, Apocynaceae, Boraginaceae, Compositae, Convolvulaceae, Plantaginaceae, Scrophulariaceae). Most hosts showed either mottle or ringspot. Local lesions were produced on *Sesbania exaltata*. No local-lesion host was found for virus A. *Cyamopsis tetragonalobus* was the only species susceptible to virus A which was not also susceptible to virus B.

Relative ability of four races of Puccinia graminis tritici to overwinter in Texas. Futrell, M. C., and A. J. Pilgrim. Four varieties of wheat were seeded in 1954 in 12 × 12 ft. plots at 6 locations ranging from the northern to the southern part of Texas. These varieties were inoculated with races 15B, 17, 38, and 56 of the stem rust fungus. The overwintering capacity and relative pathogenicity of each race were studied on the 4 varieties. No race lived through the winter north of Waco. At the 4 stations south of Waco, no race was killed completely on all varieties. Race 15B on the variety Nugget was the most aggressive. Bacterial parasites of the stem rust fungus reduced the incidence of the disease during the winter. Bacteria were most prevalent at stations of high rainfall and high humidity, and appeared to be more aggressive on some races of the stem rust fungus than on others. The fungus did not overwinter as efficiently on wheats of decumbent growth as on wheats of upright growth habit.

Chenopodium album, local-lesion indicator plant for carnation mosaic virus. Gasiorkiewicz, E. C. When *Chenopodium album* was mechanically inoculated with carnation mosaic virus, it reacted by the production of local lesions in 7 days. The lesions produced were discreet bright yellow flecks with red margins. There was no difference between young and old leaves in the number of lesions produced. Lesions, however, were most pronounced on older leaves in 7 days, whereas initial symptoms on younger leaves were distinct mottled areas followed by lesions similar to those on older leaves. Symptoms were identical when carnation mosaic virus was obtained from infected carnations and from infected *Dianthus barbatus*. The virus was recovered by reinoculation to *Dianthus barbatus* and carnation seedlings. Because of the distinct lesions produced on *Chenopodium album*, this plant species was found to be a suitable host for quantitative assay of carnation mosaic virus.

Endoparasitism of a spiral nematode on African violet. Golden, A. M. In a preliminary study of African violets naturally and experimentally infested with *Rotylenchus brachyurus* Steiner 1938, it was found that this nematode not only attacked the roots and crown ectoparasitically but invaded them as an endoparasite, living primarily within the cortical areas. Furthermore, within the crown, the organism apparently acted both as an intercellular and an intracellular parasite, an observation not previously reported. In the cortex of the crown, 1 or more mature specimens often with deposited eggs could be found coiled within an individual cell, whereas in other cases the organism had penetrated the wall of the adjoining cell. Sometimes several eggs were seen within a single cell. Larvae hatched from these eggs sometimes developed and filled the cell completely before migrating through the wall to adjacent cells.

In the roots, the organism damaged and destroyed the cells as it fed upon and moved through them. Eggs were deposited in the cortical tissue, evidently forming nests of several specimens such as were found in the larger roots. Some nematodes were observed only partially embedded in the roots and crown. A brownish discoloration was evident in all nematized areas.

Identification and distribution of plant parasitic nematodes in Florida and Georgia. GOOD, J. M., J. R. CHRISTIE, AND J. C. NUTTER. Bermuda grass, St. Augustine grass, Centipede grass, and Zoysia grass may be severely injured by nematodes. A total of 133 turf samples from representative areas in peninsular Florida were examined. The sting nematode, *Belonolaimus gracilis*, and the lance nematode, *Hololaimus coronatus*, appear to cause most injury. The lance nematode is the most important parasite of St. Augustine grass, and it was found frequently around the roots of the other grasses. On St. Augustine grass it usually feeds as an internal parasite, producing extensive destruction of the root tissues. On the other grasses it feeds primarily from the outside. The spiral nematodes, *Rotylenchus* spp., have been found associated with turf injury on a number of occasions, but the damage they cause is difficult to evaluate. *R. erythrinae, R. coheni,* and an undescribed species prevalent in the Tampa Bay area were the species most frequently encounterd. Stubby-root nematodes, *Trichodorus* spp., and several ring nematodes of the genus *Criconemoides* were found frequently on turf in Florida, but seldom in large numbers. In Georgia, sting nematodes and stubby-root nematodes appear to be the major pests of Bermuda and Zoysia grasses, but ring nematodes have been found in large numbers.

Damping-off of Ladino clover and Lespedeza as affected by temperature and soil moisture. GRAHAM, J. H., V. G. SPRAGUE, AND R. R. ROBINSON. A series of experiments was conducted to determine the pre-emergence and postemergence damping-off of Ladino clover and Lespedeza by *Fusarium roseum, Pythium debaryanum,* and *Rhizoctonia solani* at 7 temperatures and 3 levels of soil moisture. The most favorable temperatures for mycelial growth of both Fusarium and Rhizoctonia were 66–80°F and of Pythium, 66–87°F. Optimum temperatures for most rapid seedling emergence of Ladino clover were 66–73°F and of Lespedeza, 80–94°F. Analysis of variance showed highly significant interactions among the various factors studied. In general, most pre-emergence damping-off of clover by the 3 fungi occurred at 80–94°F and most postemergence damping-off at 59–73°F. With Lespedeza, pre-emergence damping-off was moderate at 52–66°F. Postemergence damping-off by Rhizoctonia and Pythium was very severe at 59–87°F, whereas Fusarium was active at 52–66°F. For both host species, Fusarium was most active in moderately dry soil and Pythium in wet soil (near saturation); Rhizoctonia was little affected by soil moisture.

Diffusion of soil fumigants in tobacco row treatments. GRAHAM, T. W. Fumigants were applied at the bottom of a 6-in. furrow and covered immediately with a plow. Four furrows were plowed over the treated row, leaving a ridge covering the fumigant 10 in. deep. One week later (March 24), soil samples were taken in a regular pattern in relation to the point of application. Low counts of nonparasitic nematodes from D-D mixture (1,2-dichloropropane; 1,3-dichloropropene) and ethylene dibromide (W-40) treatments indicated that fumigants were well distributed throughout the row bed. D-D treated rows sampled at 4, 8, and 12 in. horizontally from the injection point averaged respectively 2, 22, and 161 nematodes, and those from rows treated with ethylene dibromide had 25, 61, and 112, respectively. Untreated rows at these points averaged 360, 239, and 224, respectively. Counts in samples above the application point indicated a similar upward diffusion of fumigants. In all cases, nematode populations were lowest at points nearest the application point. There was an effective zone of fumigation 8–12 in. horizontally on each side of the injection and in an 8-in. arc above. Root knot development on tobacco roots in August confirmed the above results and gave an average disease index of 14 in treated rows and 66 in nontreated ones.

Testing canning pea seed for adequacy of seed treatment. HAGEDORN, D. J. One hundred twenty-five samples of canning pea seed, representing 45 varieties supplied to 11 canning companies by 15 seed organizations, were tested to determine if commercial treatment with seed protectants had been adequate to safeguard the seed from severe damping-off conditions. The technique used was an adaptation of the cold test commonly used for corn and involved germinating seed in infested soil rolled in paper towels. Seventy-five per cent of these samples germinated less than 60 per cent. Only 10 per cent of the samples germinated over 81 per cent. Seed treated commercially with dichlone (as Phygon) or captan (as Orthocide) germinated better than that having chloranil (as Spergon) treatment. None of the companies had consistently done an adequate job of seed treatment. When all seed was retreated with captan, 71 per cent of the samples germinated 90 per cent or more, and none were rated lower than 82. Captan and dichlone were more effective than thiram (as Arasan) or chloranil as retreatment materials. In general, Alaska, Early Sweet, Perfection, and Wales varieties did not differ markedly in benefit derived from retreatment.

Physiologic races of Ustilago tritici in Kansas. HANSING, E. D. The standard differential wheat varieties Wabash, American Banner, Purdue No. 1, Hussar, Early Premium, Nabob, Forward, Trumbull, Kangip, and Leap were each inoculated with each of 126 collections of *U. tritici.* Eight collections from the varieties Triumph, Tenmarq, Comanche, and Iobred were identified as race 1; 2 from Early Premium as race 3; 3 from Vigo as race 6; 12 from Tenmarq, Ponca, Westar, Pawnee, Turkey, Blackhull, and Fulcaster as race 10; and 101 from Comanche, Wichita, Tenmarq, Turkey, RedChief, BlueJacket, Early Blackhull, Blackhull, Kiowa, Clarkan, Stafford, Cheyenne, Chiefkan, Redjacket, Kan-Queen, Pawnee, Triumph, Kanred, Nebred, MoKing, Royal, and Harvest Queen as race 11. Physiologic races 1, 10, and 11 were distributed generally in Kansas, whereas races 3 and 6 occurred only in Eastern Kansas. Pawnee and Kawvale were highly resistant whereas Ponca, Triumph, and Vigo had good resistance to all races. Kiowa, Cheyenne, Royal, and all of the 10 "Blackhull" varieties were highly resistant to races 1 and 10, susceptible to race 11, and variable in reaction to races 3 and 6. Westar and Quanah were highly resistant to race 11 and intermediate or susceptible to the other races. Wichita, Comanche, Tenmarq, Turkey, Kharkof, Kanred, Nebred, and Iobred were intermediate or susceptible to all 5 races.

Effects of temperature on damping-off and response to seed treatment in forage legumes. HANSON, E. W. The effects of temperature and seed treatment on stand, at emergence and 15 days after seeding, were determined in naturally infested Carlisle muck soil in the greenhouse at 16°, 20°, 24°, and 28°C. The legumes used were Kenland red clover, Ranger alfalfa, and Common Yellow sweetclover. Arasan (50 per cent thiram), Orthocide 75 (75 per cent captan), Phygon (50 per cent dichlone), and Vancide 51 (30 per cent sodium dimethyldithiocarbamate and sodium derivative of 2-mercaptobenzothiazole) were the fungicides tested. Adequate checks (no treatment) were included in all trials. Most pre-emergence and postemergence damping-off occurred at the higher temperatures. Least disease and best stands developed at 16°C. Seed treatment was very effective in reducing pre-emergence killing but did not control postemergence damping-off. Alfalfa and sweet clover were more susceptible than red clover to both phases of damping-off and showed more benefit from seed treatment. All of the fungicides tested improved stands at all temperatures. There were no significant differences among fungicides at any of the temperatures on red clover. On alfalfa, Orthocide proved superior to Arasan at 20°C, but

there were no significant differences among fungicides at the other temperatures. On sweetclover, there were no differences at 16°C, but Orthocide and Vancide were superior at the other temperatures.

Effects of air-pressure inoculation, buffers, and preinoculation environment on virus infection in clovers. HANSON, E. W., AND D. J. HAGEDORN. Alsike clover, crimson clover, red clover, and sweetclover were inoculated with alfalfa mosaic virus, red clover vein-mosaic virus, and yellow bean mosaic virus to determine the effects on infection of 1) air-pressure inoculation, 2) buffers, and 3) preinoculation environment of the plants. When virus inoculum was mixed with Carborundum and applied by atomization at air pressures of 10, 20, and 30 lb., the average percentages of infected plants in terms of those inoculated by rubbing were 58, 66, and 82 per cent, respectively. When inoculation was by rubbing, neither potassium phosphate nor sodium phosphate buffers, added to the viruses at concentrations of 1:1, 1:10, or 1:100 (buffer:virus), increased infection more than 18 per cent as compared to inoculations with no buffer. The average increase was 4 per cent. No benefits were obtained from either buffer with the yellow bean mosaic virus. Ten-day preinoculation treatments of 4, 8, or 16 hours daylight at 15°, 20°, and 25°C had little or no effect on susceptibility of the clovers to infection.

Some characters identified in cowpeas segregating for resistance to Fusarium wilt. HARE, W. W. Twenty-five lines of cowpeas originating from a single-plant selection were grown in the field in 1955. Segregation for resistance to Fusarium wilt and for plant type had been observed in 2 previous generations and selections made for wilt resistance and for commercial types. Counts were made of plants showing differences in pod types and pod colors when maturing. Segregation ratios were obtained that indicated dominance of yellow pod color over "golden," yellow over red, small slender pod over baby crowder type, and long pod over short crowder. In 1 line, yellow:red:small slender: baby crowder segregation was 9:3:3:1. In 2 lines, pod size segregated 1 large, 2 intermediate, and 1 small. All characters described apparently were controlled by single genes. Supporting evidence was available in other lines that were pure for specific characters. No progeny selected for its recessive character in the previous generation segregated, and 7 lines were pure for the dominant and 23 for the recessive characters. Resistance or susceptibility to Fusarium wilt was not closely linked to any of the characters described. Differences were observed in yield, vine type, and maturity, characters that could not be reduced to objective measurements.

A major gene for resistance to root-knot nematodes in pepper. HARE, W. W. All bell pepper varieties tested have been susceptible to the root-knot nematode, *Meloidogyne incognita* var. *acrita*. Four small-fruited hot peppers were rated highly resistant. In comparative tests with a few varieties from each group, 2 previously rated resistant were resistant to *M. incognita*, *M. arenaria*, and *M. javanica*. Bell pepper varieties previously rated susceptible were susceptible to *M. incognita* but varied in reaction to *M. arenaria* and *M. javanica*. All peppers tested were susceptible to *M. hapla*. Evidence from F_1, F_2, F_3, and backcross generations of one of the resistant peppers crossed with 2 commercial bell varieties and F_1, F_2, and F_3 of a second resistant pepper crossed with 3 commercial bell varieties fitted the hypothesis that resistance to *M. incognita* is controlled by a single gene with resistance dominant to susceptibility. Further, the same gene controlled resistance to *M. incognita* var. *acrita* and possibly to *M. javanica* and *M. arenaria*. Behavior in both sets of crosses was similar, suggesting that the same gene pair was involved.

Fumigation of encysted golden nematode larvae under controlled environmental conditions. HARRISON, M. B., AND W. F. MAI. Encysted golden nematode larvae were exposed to the vapors of D-D (1,2-dichloropropane; 1,3-dichloropropene), chloropicrin (trichloronitromethane), ethylene dibromide (1,2-dibromoethane), and Vapam (sodium *N*-methyl dithiocarbamate) in glass fumigation chambers. The relative humidity of the environment prior to and at the time of fumigation was controlled with either saturated salt solutions or sulfuric acid solutions. No significant difference could be detected in the percentage of larvae that survived the fumigation treatments when they were conducted at 10°, 20°, or 30°C. The degree of control was in direct proportion to the relative humidity at the time of fumigation, and at the highest relative humidity, control was more than 90 per cent greater than at the lowest relative humidity. Maintaining the encysted larvae at a high relative humidity for 2 weeks prior to fumigation increased the efficacy of the treatment.

Differences in infectibility among spring wheat varieties exposed to spore showers of race 15B of Puccinia graminis var. tritici. HAYDEN, E. B. Severe crop losses from stem rust occurred in the hard red spring wheat area of the United States in 1950, when race 15B first became prevalent, and in 4 of the 5 succeeding crop years. Marked differences in yield between bread and durum wheats and among varieties within each class were evident, although all varieties were severely rusted. Progressive development of stem rust on certain varieties was observed critically during the past 2 years. Differences in prevalence and severity evident early in the season often became obscured as epidemics developed. Light and heavy spore showers, 2,250,000 and 57,450,000 urediospores, respectively, were applied to areas of 2 sq. ft. in plantings of 11 spring wheat varieties. Although conditions were unfavorable for infection until the fifth day after inoculation, the average number of lesions that developed on varieties inoculated with 2,250,000 spores ranged from 0.025 per culm on Sentry (C.I. 13102) to 5.25 on Marquis (C.I. 3641). The number of lesions on varieties inoculated with 57,450,000 spores ranged from 1.5 on Sentry to 23.5 on Marquis. Differences in infectibility among varieties evident early in the growing season but often obscured at maturity may be one of the factors responsible for marked differences in yield of certain rust-susceptible spring wheats.

Mode of action of the wet anaerobic storage treatment for the control of loose smut in barley. HEBERT, T. T. Loose smut of barley, caused by *Ustilago nuda* (Jens.) Rostr., was controlled by soaking infected grain in water at room temperature for 15 minutes to 4 hours and then storing it in air-tight containers for 36 hours at 32°C, 48 hours at 28°C, or 60 hours at 24°C. Spores on water agar lost viability when held for 24 hours at 28°C in a closed container with soaked barley seed or in a container from which oxygen had been removed with alkaline pyrogallol. When week-old cultures of *U. nuda* on potato-dextrose agar slants were placed in an oxygen-free atmosphere, they were not viable after 36 hours at 32°C, 48 hours at 28°C, or 60 hours at 24°C. There was a close correlation between the length of time the fungus mycelium survived at various temperatures on agar slants in the absence of oxygen and in infected seed under anaerobic conditions. The inability of the fungus to survive after removal of oxygen from the closed containers by respiration of soaked seed appears to be the principal factor in control of loose smut by this method.

Exudates produced by phytopathogenic bacteria. HEDRICK, H. G. The species of phytopathogenic bacteria producing exudates are found in the genera *Bacterium*, *Corynebacterium*, *Erwinia*, *Pseudomonas*, and *Xanthomonas*. The exudates produced by 16 species in these genera were investigated. The highest yields of exudate were obtained on media containing sucrose or glucose as the source of carbon in a basal casein hydrolysate medium. All of the exudates are acidic and upon hydrolysis yield sugar units. Each of the hydrolyzed exudates appeared to contain 3 or more of the following sugar units as determined by paper chromatography: glucose, mannose, fructose, rhamnose,

xylose, ribose, and galacturonic acid. Excised sunflower and tomato plants wilted rapidly when placed in aqueous solutions of various concentrations of the exudates, indicating a mechanical blocking of the vascular system by the large molecules of the polysaccharides. The high water-holding capacity of the exudates suggests that they may aid in the survival of the pathogens in unfavorable environmental conditions. Experiments showed that when a thin film of wet or dry exudate was placed between a culture of *Escherichia coli* and an ultraviolet light source the bacteria were protected for several minutes.

Fanleaf virus of grapevines is soil borne. HEWITT, WM. B. When old fanleaf-diseased grapevines are removed from the soil in the fall and the spaces replanted to healthy vines the following spring, the new plants become diseased within the second and third seasons. In March, 1954, soil was dug from the base of fanleaf-diseased vines in 2 separate vineyards and placed in 3-gal. tin cans. These cans of soil, equal numbers from each vineyard, were planted as follows: 20 were planted each with 1 diseased vine from the same vineyard where the soil was collected and 1 healthy St. George rooting, *Vitis rupestris;* 20 were planted each with 1 healthy St. George rooting; 10 were planted each with 3 healthy cuttings of the variety Mission; 10 of steam-pasteurized soil were planted each with 1 healthy St. George rooting; and 10 cans of Davis greenhouse potting soil were planted each with 1 healthy St. George rooting. All were maintained in a lath house at Davis, California. In June, 1955, all St. George and Mission vines planted in natural vineyard soil from the base of fanleaf-diseased vines showed symptoms of fanleaf, whereas all St. George vines planted in steam-pasteurized vineyard soil and in Davis potting soil did not show symptoms of fanleaf.

Yellow vein, a disease of grapevines caused by a graft-transmissible agent. HEWITT, WM. B. Diseased vines fail to set fruit, or they set only a small amount of fruit with straggly clusters that contain many shot (seedless) berries. Some leaves show blotches of yellow speckling over the leaf surface. After about midseason, other leaves develop a chlorotic vein banding that advances into a yellow vein banding or broad "yellow veins." Diseased vines are often more vigorous than normal vines. An agent causing these leaf symptoms has been transmitted by chip-bud grafts from diseased vines of the variety Carignane to young healthy Carignane, Emperor, and Mission rootings and from diseased vines of the variety Emperor to young healthy rootings of Emperor, Carignane, and Mission.

A morphological comparison of two cyst nematodes, Heterodera glycines and H. trifolii. HIRSCHMANN, HEDWIG. Cysts and second stage larvae of the soybean nematode, *Heterodera glycines* Ichinohe and the clover nematode, *H. trifolii* (Goffart) Oostenbrink were compared. Consistent differences in morphology were found that make a separation of the 2 species possible. Surface markings of the cysts were the same in both species except for a somewhat less pronounced punctation in *H. trifolii* then in *H. glycines.* The average length and breadth ratios of the 2 species differed only slightly. The most significant morphological differences between the 2 species were found in the second-stage larvae, which differed greatly in body and stylet length, in distance of dorsal gland orifice behind stylet knobs, and in tail and tail terminal length. Measurements of these characters were made on 5 larvae from each of 30 cysts of the 2 species. In no case did the means of these characters overlap in the 2 species. There were also distinct differences in the shape of stylet knobs and tail in the 2 species.

Effectiveness of ethylene dibromide, D-D, and Nemagon in controlling the sting nematode on sandy soils in South Carolina. HOLDEMAN, Q. L. Three years of field trials for the control of the sting nematode, *Belonoliamus gracilis,* conducted on a deep sandy soil of low fertility in northeastern South Carolina demonstrated that ethylene dibromide (EDB-85) was more effective than D-D (1,2-dichloropropane; 1,3-dichloropropene) when applied as an in-the-row treatment at commercially competitive rates. Yield data of sweet potatoes in 1953 and 1954 consistently showed higher yields following the application of EDB-85 at ¼ pint/160 ft. (approximately 2 gal./acre) than following application of D-D at 1 pint/160 ft. Nemagon (1,2-dibromo-3-chloropropane), included in the 1954 test at ¼ pint/160 ft., gave excellent nematode control, yet the yield was consistently lower than the yield from nontreated plots. In 1955, soil samples from under soybeans revealed a lower population of sting nematodes in treatments receiving EDB-85 at the ⅛-pint rate than in treatments receiving D-D at the 1½-pint rate. D-D plots treated at 1½ pints/160 ft. were reinfested within 2 months following application, whereas EDB-85 at ¼ pint lasted 4 months. Nemagon at 1/16 pint gave results comparable to the latter.

Relatedness of ovary length and rate of reproduction in plant nematodes. HOLLIS, JOHN P., AND MAX J. FIELDING. The ratio of ovary length to female nematode body length (O/B), expressed as a percentage, was determined for 240 species of plant nematodes. The term ovary refers to that portion of the gonad containing immature ova. These data were correlated with reproduction rates (RR) of the species, based upon 1) W. J. Martin's work on build-up of pure populations of individual nematode species in the greenhouse, 2) the prevalence and populations of individual nematode species from several thousand soil samples from root regions of crop plants in Louisiana, and 3) the available literature. Sedentary tylenchs of the genera *Meloidogyne, Heterodera, Nacobbus, Tylenchulus,* and *Rotylenchulus* exhibit rapid RR and possess O/B values greater than 100 per cent. Migratory tylenchs, aphelenchs, and rhabditids possess O/B values of 35.1, 28.1, and 32.2 per cent, respectively, and moderate RR. The genera *Dorylaimus, Xiphinema,* and *Monochus* yielded O/B values of 18.4, less than 16.8, and less than 15.5 per cent, respectively, and exhibit low RR. Such data might be applied in studies on changes in nematode populations.

A method of testing fungicides in the laboratory for controlling Botrytis fruit rot of strawberries. HORN, NORMAN L. Immature berries in the white stage were immersed in suspensions containing one of various fungicides and conidia of the organism *Botrytis cinerea.* The fruit were placed immediately in a specially constructed high-humidity chamber at approximately 75° F. The number of berries that rotted in each treatment was recorded. Two controls were used. One was untreated fruit and the other was fruit dipped in a conidial suspension only. Each test was run 6 days. Of the approximately 140 materials tested, including organic and inorganic fungicides and antibiotics, the rot was less when some of the mercury-containing compounds such as *N*-phenylmercuriethylenediamine, phenylmercury dimethyldithiocarbamate, and mercurous mercury were used. These materials were nontoxic to the berries at concentrations sufficiently high to give good control of the organism. Endomycin was the most effective antibiotic tested. Captan was considerably less effective than the mercury compounds; however, captan-treated berries were less than 45 per cent rotted as compared to the inoculated controls, which were nearly 100 per cent rotted.

Effect of ketones on sporulation of Monilinia fructicola. HORSFALL, JAMES G. Ketones and carboxylic acids in general suppress sporulation of *M. fructicola* growing on casein hydrolyzate agar. Alpha and β unsaturated ketones and acids, however, tend to enhance sporulation. Examples are 2-butene-1-one, dibenzalacetone, pulegone, 4-chloro-1,2-quinone dioxime, and 2,3-dichloro-1,4-naphthoquinone; itaconic, aconitic, maleic, coumaribic, *o*-chlorocinnamic, and crotonic acids; crotonamide; and the β-ethoxyethyl ester of crotonic acid. Fumaric acid failed to stimulate sporulation because of steric hindrance. It is suggested that these compounds suppress the action of natural inhibitors by forming addition compounds with such reactive groups as amino or sulfhydryl groups.

Mode of pathogenesis of Pseudomonas solanacearum. HUSAIN, A., AND ARTHUR KELMAN. The role of enzymes and other substances produced by *Pseudomonas solanacearum* was investigated in relation to mode of pathogenesis. In 24-hour shake cultures of a pathogenic isolate, pectic enzyme activity was high, and both pectin methyl esterase and polygalacturonase were present. Rapid decrease in viscosity of a carboxyl-methyl-cellulose solution following addition of culture filtrate indicated that high levels of a cellulosic enzyme (Cx) also were produced. When culture filtrate showing high pectic enzyme activity was tested on tomato cuttings, severe wilting developed within 5 hours in cuttings placed in heated and nonheated filtrate. Cuttings placed in a similar culture filtrate of an avirulent strain did not wilt. Vascular fluid extracted by suction from diseased Rutgers tomato and Bottom's Special tobacco plants induced wilting in healthy cuttings of these hosts, whereas extracts from healthy plants did not. The toxic principle in vascular fluid from diseased plants was heat-stable. Inasmuch as wilt-inducing ability of culture filtrate was not greatly reduced following heat treatment, heat-labile pectic or cellulosic enzymes may not be primary agents involved in wilting mechanism of *P. solanacearum*. They are associated, however, with the decay of parenchyma and phloem tissues characteristic of the disease.

Reaction to crown rust of Victoria blight resistant oats selected from Victoria-derived commercial varieties. IVANOFF, S. S. Selections resistant to *Helminthosporium victoriae* were made from Victoria-derived oat varieties (Victorgrain 48-93, Arlington, and others) by the laboratory mass-screening method previously described. They were tested also for resistance to crown rust (caused by *Puccinia coronata*) in the greenhouse and field at different growth stages. Some selections, inoculated in the greenhouse with races 45 and 57, proved highly susceptible at all stages. Other selections showed high susceptibility at seedling stage, but they showed progressively increasing resistance from juvenile through adult stages. In no case, however, was the rust resistance of these selections as high as that of the blight-susceptible commercial varieties from which they were obtained. Results from field tests in 2 years under natural rust infections paralleled the greenhouse findings. Most of these Victoria blight resistant selections resembled the parent varieties in appearance and seemed to react to smut and mosaic as did the parents.

A head smut resistant strain of rescuegrass from Uruguay. JOHNSON, HOWARD W. Seed of Chapel Hill and La Estanzuela 157/49 (from Uruguay as P.I. No. 193,144) strains of rescuegrass (*Bromus catharticus* Vahl.) were inoculated with chlamydospores of the head smut fungus (*Ustilago bullata* Berk.) and planted as 10 paired rows at Stoneville, Miss., on November 10, 1953. The inoculum was from Raymond, Miss. Counts of smutted heads made in May, 1954, showed 0 in rows of La Estanzuela 157/49, whereas Chapel Hill rows ranged from 30 to 63 per cent (average 50). Seed of 5 strains of rescuegrass inoculated separately with 6 collections of this fungus were planted as 4 split-plot randomized blocks at Stoneville on October 10, 1954. Each sub-plot was a 9-ft. row. The head smut collections were from Auburn, Ala.; Baton Rouge, La.; College Station, Texas; Raymond, Miss.; Stoneville, Miss.; and Watkinsville, Ga. Counts made in May, 1955, showed the following mean percentages of smutted heads on the 5 strains of rescuegrass: Commercial, 91; Chapel Hill (Watkinsville, Ga.), 80; Chapel Hill (Americus, Ga.), 65; Texas 46, 38; and La Estanzuela 157/49, 3. The Uruguay strain was immune to 5 of the fungus collections but was moderately susceptible to the one from Baton Rouge. The other 4 strains of rescuegrass were susceptible to each of the 6 fungus collections. Smutted heads in rows planted with noninoculated seed ranged from 0 to 12 per cent.

Downy mildew of crimson clover and alfalfa in Mississippi. JOHNSON, HOWARD W., R. A. KILPATRICK, AND DOUGLAS C. BAIN. Downy mildew was found on crimson clover (*Trifolium incarnatum* L.) at McNeill, Miss., on March 4, 1955, and at Stoneville, Miss., on April 19, 1955. These are the first reports of this disease on crimson clover in the United States. Conidia from crimson clover leaves were globose and 17–23 μ. Oospores developed in infected leaf fragments placed on microscope slides in Petri dish moist chambers. They were globose, were 26–39 μ in diameter, and had brown reticulate epispores. The conidia of the fungus causing alfalfa downy mildew, which occurs in Mississippi each spring, were broadly elliptic and 20–23 $\times$ 23–33 μ. The oospores were globose, were 29–39 μ in diameter, and had brown reticulate epispores. The conidiophores of each fungus were fasciculate and branched 5–8 times at acute angles, with the ultimate branchlets subequal and arising at right or obtuse angles. Both isolates fit fairly well the description for *Peronospora viciae* (Berk.) D By. This fungus has been reported on crimson and white clovers in Europe and on common vetch, on Austrian winter pea, and on garden pea in the southern United States. Neither fungus fits the description for *P. trifoliorum* D By., the downy mildew fungus reported on alfalfa and clovers in the United States, since the oospores of the latter species have smooth-walled epispores.

Studies on root rot control by microorganisms antagonistic to Pythium arrhenomanes. JOHNSON, LEANDER F. It has been shown that some microorganisms antagonistic to *Pythium arrhenomanes* Drech. have the ability of controlling Pythium root rot of corn in greenhouse tests. Other microorganisms that exhibit the same degree of antagonism in agar cultures, however, produce no control of the disease. These studies represent attempts to determine why microorganisms react differently in the soil. Three actinomycete isolates, one of which did not control root rot, were added individually to pots of previously sterilized soil infested with Pythium. Microbial populations were determined from the rhizosphere and nonrhizosphere of corn plants grown in these soils. In all 3 cases a larger microbial population developed in the rhizosphere than outside the rhizosphere. The isolate that produced no control of root rot multiplied in and outside the rhizosphere as much as did the 2 isolates that produced good control. The liquid growth media from 10 antagonistic actinomycete and fungal isolates were treated with a Sharkey clay soil. The media were filtered and tested for loss of activity to Pythium. No loss occurred in any of the media from the 5 isolates that controlled root rot; however, partial or complete loss of activity occurred in the media from 3 of the 5 isolates that did not produce control.

Studies on the etiology of blotchy ripening. JONES, JOHN PAUL, AND LEONARD J. ALEXANDER. Blotchy ripening, a tomato fruit disorder, has increasingly become one of the major problems of the greenhouse industry of southern Ohio. A variety trial, conducted on the spring crop of 1955, was initiated in a Cincinnati commercial greenhouse where the incidence of the disease previously had been high. The results indicate that the pink-fruited variety Strain A. Globe possesses a moderate degree of resistance whereas the red-fruited varieties Stokesdale and Rutgers are highly susceptible. An experiment was begun at the Ohio Agricultural Experiment Station in January of 1955 to test the effect of potassium, of tobacco mosaic virus infection, and of temperature upon the incidence of blotchy ripening. The number of diseased fruits increased as the potassium level decreased when plants were subjected to low temperatures followed by high temperatures. When plants were subjected to normal temperatures this correlation did not hold. At both temperatures, however, the amount of blotch was decreased in high-potassium cultures. The effect of tobacco mosaic virus infection upon the incidence of blotchy ripening was variable and not conclusive.

Factors influencing viability and variation in cultures of Pseudomonas solanacearum. KELMAN, ARTHUR. The influence of temperature, type of medium, and method of storage on viability and variation in colony type of *Pseudo-*

monas solanacearum was investigated. Cultures of virulent isolates were stored in broth and on agar slants, 1 series of slants being covered with sterile mineral oil. Media contained the following N sources: tryptone + yeast extract, beef-extract + peptone, potato extract, peptone + Casamino acids, and ammonium nitrate. In addition, bacterial suspensions were stored in tap water, distilled water, and phosphate buffer (pH 7.0.). One series of cultures was stored at 5±2°C and a second at 21±3°C. Loss in viability was more rapid at 5°C than at 21°C. Percentage of colony variants of avirulent type remained below 1 per cent at the lower temperature. After 220 days at 21°C in tap water, distilled water, or buffer, bacteria were viable and percentage of variants was less than 1 per cent for 4 of 5 isolates. At 21°C, variants developed most rapidly in broth and least rapidly on oil-covered agar slants. In media with organic N sources, number of variants was highest with tryptone-yeast extract and lowest with potato extract. Aeration of broth cultures by shaking resulted in decrease in rate of development of variants.

Effect of depth of seeding on the incidence of dwarf bunt. KENDRICK, EDGAR L. Orin wheat seeded on the surface and 1 in. deep in soil naturally infested with the dwarf bunt fungus had a much higher incidence of the disease than when seeded 2.5 and 4 in. deep. Although the natural infestation was not uniform throughout the plot, the average infection percentages in 16 replications were 45, 35, 20, and 14, respectively, for surface-, 1-, 2.5-, and 4-in. seeding depths. Under conditions of uniformly heavy infestation, even wider differences might be expected. For example, 1 replication had 78 per cent dwarf bunt in the surface-seeded row in contrast to 24 per cent in the adjacent row that had been seeded 4 in. deep. This influence of seeding depth was evident in 2 dates of seeding, but the date of seeding as such had no apparent effect on the amount of infection. The relatively high percentage of dwarf bunt produced in surface and near-surface seedings in naturally infested soil not only suggests that this method may be a valuable aid in dwarf bunt studies, but also offers a clue to certain unknown aspects of the life cycle of the dwarf bunt fungus.

Pigmentation of the culture medium as an indicator of sex compatibility factors in Tilletia caries. KENDRICK, EDGAR L., AND C. S. HOLTON. An apparent association between pigmentation of the agar medium and sex compatibility factors in *Tilletia caries* (D.C.) Tul. was observed in monosporidial isolates of races T-10 and T-16 growing on potato 1 per cent sucrose agar. After 2 weeks' growth, each of 5 complete or near-complete sets of monosporidial lines from single spores could be separated into 2 groups by the difference of a rust-brown color produced by some but not by others. Compatibility relationships as determined by sporidial fusions in culture showed that within each group of lines from a single spore, the pigmenting and nonpigmenting isolates were of opposite sex. The pigmentation factor is not linked to a specific compatibility group, since pigmenting lines from different spores are sometimes of opposite reaction. This phenomenon has potentialities as a technique in genetic studies of the bunt fungi where large numbers of compatibility relationships must be determined. Its usefulness may be limited to certain races, however, since there is some evidence that pigmentation and compatibility relationships are not correlated in all races of *T. caries.*

Bacterial isolates and environmental factors in relation to geranium blight. KIVILAAN, A., AND R. P. SCHEFFER. Stem rot and blight of *Pelargonium zonale,* caused by *Xanthomonas pelargonii,* commonly occur as latent infections in commercial stocks. From each of 6 standard varieties, which originally appeared healthy, 100 plants were selected and kept under conditions precluding dissemination of pathogens. Within 3 months, 10.3 per cent of the plants developed typical symptoms, and causal bacteria were isolated from them. Experiments with 12 isolates showed that 3 weeks or more were needed for first symptoms to show if night temperature was 20°C, whereas plants at 28°C developed symptoms 3–7 days after inoculation. When plants were grown in sand culture with a series of balanced nutrient levels, disease development was most rapid at levels below optimum for growth. Bacterial isolates, differing quantitatively and qualitatively in their effects on hosts, fell into 3 classes . The most common type caused stem rot but not leaf spot in standard varieties, but it did not affect geranium seedlings. A second type caused stem rot but not leaf spot in both standard varieties and seedlings, whereas a third type caused both stem rot and leaf spot in standard geranium varieties and in seedlings.

Experimental control of pathogenicity of biochemical mutants of Venturia inaequalis. KLINE, D. M., D. M. BOONE, AND G. W. KEITT. Eight biochemical mutants of *Venturia inaequalis* previously reported by workers in this laboratory to be nonpathogenic or only slightly pathogenic were supplemented with their respective required nutrilites following inoculation. Pathogenicity to apple leaves susceptible to the wild-type line from which the mutants were derived was restored wholly or in large part to those mutants requiring choline, riboflavin, uracil, arginine, methionine, or histidine when solutions of the required nutrilites were applied daily to the leaf surfaces after inoculation. The minimum number of days of supplementing sufficient to restore pathogenicity varied among these mutants. The pathogenicity of mutants requiring adenine or guanine was not restored by similar supplementation. Sap expressed from apple leaves supported growth of all 8 mutants except the one requiring histidine.

The effect of virus infection on yield, flowering, and chemical composition of Ladino clover. KREITLOW, K. W., O. J. HUNT, AND H. L. WILKINS. Susceptibility to virus diseases is one of the factors affecting yield and persistence of Ladino clover. In order to evaluate critically the damage caused by virus infection, identical clonal material of healthy and virus-infected Ladino clover was compared. Highly significant differences in yield were obtained in both greenhouse and field. In greenhouse tests conducted in nutrient culture, yield of dry matter from virus-infected Ladino clover was reduced an average of 48.4 per cent. In field tests with comparable clonal material, yield from virus-infected plants was reduced as much as 54.3 per cent. Virus infection reduced flowering by 31.7 per cent in the greenhouse. Chemical analyses indicated that virus-free Ladino clover contained a greater percentage of ash, crude fiber, and ether extractable substances than did infected material. Virus-infected clover contained a higher percentage of crude protein and nitrogen-free-extract than did healthy material.

Overwintering and control of Xanthomonas vesicatoria. KRUPKA, L. R., AND D. F. CROSSAN. Studies on the overwintering and control of *X. vesicatoria* were carried out in the greenhouse, laboratory, and field in 1954-1955. Twelve 10-in. pots filled with steamed soil were artificially infested on September 15 by the addition of pepper leaves infected with *X. vesicatoria* and placed outdoors. Six pots were moved to the greenhouse in March and seeded with pepper seed that had been treated with mercuric chloride. Another 6 pots were moved to the greenhouse in June and similarly seeded. Seedling infection occurred in all of the pots, indicating the organism can persist at least 9 months in refuse of infected plants. Artificially infested seed treated 5 minutes in mercuric chloride solution (1-1000) and 5 minutes in a streptomycin solution (200 ppm) were germinated in steamed soil. The percentage of infected seedlings occurring was as follows: mercuric chloride, 0; streptomycin, 25; and untreated, 24. In a field plot where the following materials were applied at the indicated intervals, the percentage infection was as follows: 1) untreated, 38; 2) 200 ppm streptomycin (10-day interval), 23; 3) 200 ppm streptomycin (5-day interval), 17; 4) 100 ppm streptomycin +

1 per cent glycerol (10-day interval), 8; 5) 100 ppm streptomycin + 1 per cent glycerol (5-day interval), 4; and 6) 3-100 tribasic copper sulfate (5-day interval), 17.

Studies on the tessellate stylet nematode. KRUSBERG, L. R. Host range, temperature range, longevity and reproduction studies were conducted on the tassellate stylet or "stunt" nematode, *Tylenchorhynchus claytoni* Steiner, one of the more important plant-parasitic nematodes in North Carolina. In host range tests, 42 species or varieties of crop plants were grown in 6-in. pots of soil previously treated with methyl bromide. At planting time, 200 nematodes were placed in each pot. Five pots of plants of each crop grew for 90 days in the greenhouse. On the basis of the number of nematodes recovered from the soil, plants of tobacco, corn, wheat, sudan grass, and Irish potato were very favorable for nematode buildup, and *Crotalaria spectabilis*, peanut, pepper, cucumber, and mustard were unfavorable. The average number of nematodes per pot in the former group ranged from 4400 to 6400, whereas in the latter group there were from 15 to 90. The nematode population on plants grown at various temperatures increased to a higher level on plants grown at 90°F, the highest temperature used, than at lower temperatures. The nematode can live for several months in moist soil in the absence of plants. Investigations indicate that males are necessary for reproduction.

Split-dosage applications of soil fumigants to control stem and bulb nematode on garlic in California. LEAR, BERT. Control of stem and bulb nematode, *Ditylenchus dipsaci*, affecting garlic has been obtained in California with split-dosage applications of D-D (1,3-dichloropropene, 1,2-dichloropropane) and Nemagon (1,2-dibromo-3-chloropropane). For each fumigant, equal amounts were applied in 1 application and as a split application to replicate plots in May, 1954. The split applications, each ½ the total amount, were made 10 days apart. Applications were made by machine at rates of 50 gal. per acre for D-D and 5 and 10 gal. per acre for Nemagon. Cloves of California Late Garlic were planted in December, 1954, 7 months after treatment. Counts of nematodes from soil samples and yields produced on 200 row ft. indicate that split applications of D-D and Nemagon at the indicated rates were very effective. Mean weight of commercial garlic for the check plots was 3 lb., with 861 discarded bulbs. The split application of D-D resulted in 93 lb. of garlic, with 20 discarded bulbs. Yields of 82 and 84 lb. were obtained for Nemagon at the 5- and 10-gal. rates, with 9 and 12 discarded bulbs, respectively. Bulbs produced on the Nemagon-treated plots were smaller than those from the D-D plots. Earlier experiments with the same dosages of Nemagon resulted in severe injury to garlic planted 3 weeks after treatment.

Survival of root-knot nematodes in grape and tomato roots recovered from soils fumigated with Nemagon. LEAR, BERT, AND D. J. RASKI. Data from greenhouse and field experiments indicate that Nemagon (1,2-dibromo-3-chloropropane) at dosages as high as 10 gal./acre does not penetrate nonrotted tomato or grape roots in amounts lethal to root-knot nematodes (*Meloidogyne incognita* var. *acrita*). In greenhouse tests, freshly dug grape and tomato root sections and infected living tomato plants were exposed to dosages of Nemagon in soils contained in glazed gallon crocks. Dosages equivalent to 2.5, 5.0, 10.0, and 20.0 gal./acre were used. Following exposure times of 24 hours to 1 month, roots were removed from the crocks and placed in pots of fumigated soil into which was planted a tomato plant. Gall counts indicated that the chemical penetrated roots only when applied at the 20-gal. rate. Injury to tomato plants was observed at this dosage. In field experiments, applications of Nemagon at rates of 2.5, 5, and 10 gal./acre were made by hand injector to sites of established vines of Thompson Seedless and Tokay grape varieties. Soil and root samples were removed 5 months after treatment for the Thompson Seedless plot and 3 months following treatment in the Tokay plot. Many more nematodes were recovered from root samples than from soil taken from the immediate vicinity of the roots.

Analysis of steep water in the water-soak seed treatment for the control of small grain diseases. LEBEN, CURT, RALPH W. SCOTT, AND D. C. ARNY. The supernatants from seeds soaked in water 56 hours at 26°C were examined for organic acids by means of steam distillation and ether extraction. All samples tested from 6 lots of barley, 1 of wheat, and 1 of oats contained volatile acids. These were identified by paper and column chromatography as formic and/or acetic and butyric acids. The only nonvolatile acid detected was succinic, which was found in supernatants from the 5 barley lots and 1 oat lot examined. It appears, therefore, that when small grain seed is soaked in water, a characteristic anaerobic microbial population develops. Spores of *Ustilago nuda* did not germinate or germinated poorly under anaerobic conditions. Under aerobic conditions, they did not germinate at pH 5 or 7 in a steam distillate from an oat supernatant; in a distillate (pH 7) from a barley supernatant, germination was greatly reduced. In a synthetic solution (made with the approximate concentrations of formic, acetic, butyric, and succinic acids found in supernatants from 3 seed lots) at different pH levels, germination of *U. nuda* was reduced.

A study of squash and melon mosaic viruses. LINDBERG, G. D., D. H. HALL, AND J. C. WALKER. Thirteen viruses infective only on cucurbits, from Wisconsin, California, and Florida, were divided into 2 groups, the melon mosaic group and the squash mosaic group, on the basis of physical properties and insect transmission. Viruses in the melon group were transmitted by peach and melon aphids. Activity was lost at 60°C, during 28 days ageing *in vitro*, or at a 5×10^{-3} dilution. Viruses in the squash group were not transmitted by aphids and were not inactivated at 60°C, by 28 days *in vitro*, or at 10^{-4} or 10^{-5} dilution. Purified preparations of the squash group in all cases showed, by electron microscopy, spherical particles with an average diameter of 367 A. Purification and microscopy of the melon group were not successful. The melon group contained a Wisconsin isolate obtained from infected muskmelon seed, Freitag's cantaloupe mosaic virus, an isolate from infected squash in Florida, and Anderson's watermelon and yellow watermelon mosaic viruses. The squash group contained Freitag's squash mosaic virus, 2 Wisconsin isolates from wild cucumber, Anderson's typical and latent muskmelon mosaic viruses, Freitag's cucurbit ring virus and Freitag's wild cucumber mosaic virus. The viruses in the squash group were serologically similar except for Freitag's wild cucumber virus, which also did not infect cucumber whereas all others did.

The influence of irrigation on the incidence and control of tomato anthracnose. LLOYD, P. J., AND D. F. CROSSAN. Two fungicides, maneb and zineb, were compared under irrigated and nonirrigated conditions in a split-plot experiment where the soil had been artificially infested with *Colletotrichum phomoides*. Approximately 1 in. of water was applied weekly for 4 weeks to replicated plots by overhead irrigation. No natural rainfall occurred during this period (July 1-30). Fungicides were applied 1 day prior to the irrigation, on a weekly schedule. Analysis of the number of anthracnose-affected fruit picked between August 1 and August 15 indicated that: 1) the number of infected fruit was significantly higher from irrigated plots than from nonirrigated ones; 2) the maneb fungicide (Dithane M-22) was significantly better for the control of fruit infection than the zineb fungicide (Dithane Z-78) under irrigated conditions, whereas under nonirrigated conditions both materials gave relatively the same degree of control; and 3) both fungicides gave significant control under both irrigated and nonirrigated conditions.

Disease-resistant oat selections obtained from susceptible varieties. LUKE, HERBERT H., AND H. E. WHEELER. In an effort to combine resistance to Helminthosporium blight with resistance to certain races of the crown rust fungus,

973 seedlings resistant to *H. victoriae* were obtained by screening 100 bushels of 2 susceptible varieties (50 bushels Victorgrain 48-93 and 50 bushels Fulgrain). Of these, 502 individual plants showed some degree of resistance to race 45 in 1953. Seed from 50 selections was space planted and the remainder planted in bulk in 1954. On the basis of plant, grain, and panicle characters, 16 of the 50 spaced selections closely resembled parental varieties. These 16 selections exhibited a wide range of reactions to race 202. About half were highly resistant, but none showed the rust reaction typical of the parental varieties. The bulked material was heavily inoculated with *H. victoriae* when planted. Remnant seed from the bulked selections was also tested in the greenhouse for reaction to *H. victoriae*. These tests indicated that all plants thus far tested were resistant to Helminthosporium blight. Further studies are in progress with several selections that appear to be resistant to *H. victoriae* and to race 202 of the crown rust organism.

The identity, perfect stage, and parasitism of Helminthosporium nodulosum. LUTTRELL, E. S. *Helminthosporium nodulosum* Berk. & Curt. ex Sacc. causes seedling blight, leaf stripe, and sooty heads of *Eleusine indica* (L.) Gaertn. It is characterized by obclavate, brown, thin-walled, 3- to 7-septate conidia that measure 28–70 × 11–18μ and germinate by polar germ tubes. The conidiophores are hyaline, becoming pale brown; cylindrical; and geniculate. On leaves, they are 19–53 × 4–6μ, with pestle-shaped apices 6–9μ in diameter. On heads, they are up to 154μ long and are 1 to 12 septate. *H. leucostylum* Drechs. is a synonym. *H. kusanoi* Nisikado is a closely related, if not synonymous, species. H. *hadrotrichoides* Ell. & Ev. is distinguished by its broader, consistently 3-septate conidia. *H. nodulosum* produces systemic infection of its host similar to that produced by *H. gramineum* on barley. The perfect stage was obtained in culture on gas-sterilized corn grains and barley straw on Sachs agar by mating compatible strains. It is closely related to *Cochliobolus kusanoi* (Nisikado) Drechs. ex Dast.

A comparison of cysts of Heterodera rostochiensis from roots of resistant and susceptible plants. MACDONALD, KENNETH H. Individual cysts of the golden nematode, *Heterodera rostochiensis* Woll., were studied to determine whether the few that form on highly resistant plants are as well developed as those on susceptible plants. Potato lines were selected whose resistance had been derived from 3 species: *Solanum andigenum* Juz. & Buk., *S. vernei* Bitt. & Wittm., and *S. sucrense* Hawkes. Brown cysts were taken from the roots of these plants and of Katahdin, a susceptible potato variety, and stored for 10 months. Each was then measured and placed in a separate small Syracuse dish. Equal amounts of potato root diffusate were added to each dish to stimulate hatching, and the numbers of larvae that emerged were counted. Proportionally more cysts from Katahdin produced larvae than did cysts from resistant plants. Most of the latter cysts, however, produced living young, although usually in smaller numbers than did cysts from Katahdin. In a few cases, abundant larvae were hatched from adult females taken from resistant lines of *S. andigenum* and *S. vernei*. Consistent differences in cyst volumes were not found among the various groups.

Studies in Pseudopeziza medicaginis. MACNEILL, BLAIR H., AND GEO. L. BARRON. A study has been made of certain cultural and cytological phenomena associated with *Pseudopeziza medicaginis*, a leaf-spotting parasite of alfalfa. Of the culture media tried, oatmeal agar is the only one that allows normal maturation of the ascocarp. Examination of such cultural material shows that the ascocarp is initiated by means of favoured vegetative cells, which give rise directly to chains of large, densely protoplasmic, binucleate cells. These chains ramify through the stroma and hypothecium, finally producing a finer type of ascogenous hyphae, which by crozier development form the asci. Numerous convoluted spirals are present in the young ascocarp, but no truly sexual function has been attributed to them; the possibility of these structures being apothecial rudiments is discussed. Cultures developed from single spores indicate that the fungus is homothallic.

Hot water treatment for controlling gladiolus corm-borne pathogens. MAGIE, R. O. The hot water treatment of gladiolus cormels recommended by Bald et al has been tested under Florida conditions since 1953. This treatment holds much promise for the gladiolus industry because the lack of healthy planting stocks of many commercial varieties has severely handicapped control of Fusarium yellows and of Stromatinia and Curvularia diseases. Cormels of the common commercial varieties were sufficiently dormant to tolerate soaking for 30 minutes at 57.2°C if they were harvested from April 15 through early summer and treated 6–10 weeks after harvest. Small cormels were more tolerant than large ones. Small dormant corms of some varieties tolerated treatment at 55°C for 30 minutes but were excessively injured at 1 hour. A 30-minute soak at 53.5°C killed the following fungi in cormel-size pieces of diseased tissue cut from corms: *Fusarium oxysporum* Schlecht. f. *gladioli* (Massey) Snyd. & Hans., *Stromatinia gladioli* (Drayt.) Whet., and *Curvularia lunata* (Wakk.) Boed. Cormels were inoculated with *F. oxysporum* f. *gladioli* at harvest, and 1 month later sample lots were soaked for 30 minutes at 57.2°C. Heat-treated cormels placed on agar plates yielded no growth of the fungus, whereas growth occurred from all nontreated inoculated cormels.

Gladiolus Stromatinia disease controlled by soil treatments and cultural methods. MAGIE, R. O. Over 1000 acres of the better frost-protected lands on Florida's west coast are infested with sclerotia of the dry-rot fungus, *Stromatinia gladioli* (Drayt.) Whet., to the extent that winter crops of gladiolus can not be grown profitably. Root rot is responsible for over 90 per cent of the damage by this disease in Florida. Terraclor (75 per cent pentachloronitrobenzene), Vapam (sodium methyldithiocarbamate) and Crag Fungicide 974 (95 per cent tetrahydro-3,5-dimethyl-2*H*-1,3,5-thiadiazine-2-thione) were effective in greatly reducing and delaying root infections and in producing flower crops on heavily infested soils. In those soils, a dosage rate of 200 lb./acre was needed for satisfactory control with each fungicide; in lightly infested soils 100 lb./acre was sufficient. Maximum control was not obtained unless the soil was moist and a Roto-tiller was used to mix the chemicals in the soil. Plantings made before September 15 and after January 1 escaped the disease. The disease is important only on crops planted in well-drained soils, indicating that summer flooding greatly reduces the number of sclerotia surviving in the soil.

Evidence that the nematode Pratylenchus penetrans causes losses in New York State cherry orchards. MAI, W. F., AND K. G. PARKER. At several locations, young cherry trees on light, well-drained soils have made very poor growth despite the best known cultural treatment. New root growth on the poorest trees is very sparse or absent. On trees making moderate to poor growth, a witches-broom type of root development is produced. In September, 1953, individual-tree planting sites were treated with dichloropropene at 450 lb. per acre, and trees were planted 6 weeks later . In September, 1954, terminal growth and trunk girth increase on the treated trees were 2–4 times that on the untreated checks. In 1955, the terminal growth differential was still greater. At the same time, 21 months after treatment, root examination showed approximately 29 times as many individuals of *P. penetrans* in the checks as in the treated trees. In a similar experiment started in 1954, examination in 1955 showed similar growth differences, and the population of *P. penetrans* in the roots of the check trees was approximately 50 times greater than that in the treated ones. *Xiphenema* sp. was present in the soil, and examination showed these nematodes were destroyed by the treatment, but comparatively small numbers were present even in the untreated checks.

Studies on multiplication of aster-yellows virus in tissue cultures of insect vectors. MARAMOROSCH, KARL. The reproduction of aster-yellows virus in leafhoppers previously was studied by serial passages in vectors maintained on living plants. Recently a new method of measuring virus increase by use of insect tissue cultures was developed. Two days after nymphs of *Macrosteles fascifrons* acquired virus by feeding, they were surface sterilized and cut into small pieces on Maximov slides in a solution containing antibiotics. The tissues were suspended for 10 days at 25°C in hanging drops of a medium containing salts, bovine albumin, amino acids, and mycostatin, then transferred to Ringer solution and ground in a micromortar. The resulting suspension was centrifuged, and the cell-free supernatant was inoculated into adult aster leafhoppers from stock, using an automatic microinjector. The inoculated insects were transferred at frequent intervals to aster plants held at 25°C. Of 80 groups of 3 insects each, 7 consistently transmitted aster-yellows virus after an incubation period of 28–38 days; 500 stock insects tested on 500 aster plants gave no infections, and no virus was recovered from insects ground immediately after a 2-day infection feeding. Virus was never recovered from these vectors before the fourth day of incubation. Since the virus completed its incubation in vector tissues suspended in hanging drops, the results suggest that it multiplied in these tissues.

Propagation and pathogenicity of Trichodorus sp. on cotton and other crops in Louisiana. MARTIN, W. J. Studies were made of the propagation and pathogenicity of an undescribed species of *Trichodorus* (preserved in Louisiana Nematode Collection No. 5) on cotton, corn, sweet potatoes, and soybeans. The nematode was found abundantly in certain Red River deposited soils that are planted mainly with cotton. Comparatively pure populations of the Trichodorus were established from hand-picked specimens by placing them on corn growing in sterilized soil. Subsequent controlled infestations were made with these populations. In the experiments with cotton, the nematode propagated abundantly on Coker 100 WR without causing measurable differences in stand, height, or green weight. In 1 of the 2 tests with cotton variety Deltapine 15, green weight appeared to be reduced as a result of nematode infestation. In the tests with corn (Golden Cross Bantam), sweet potatoes (Porto Rico), and soybeans (Pelican), the Trichodorus propagated abundantly on corn and soybeans, leaving little or no evidence of injury on the roots of these plants. There was comparatively little increase of the nematode on sweet potatoes, and no root injury was noted on that crop.

Fungus spores in reducing sulfur to hydrogen sulfide produce an equivalent of carbon dioxide. MCCALLAN, S. E. A., AND LAWRENCE P. MILLER. Micrometric studies show that when fungus spores or cells reduce elemental sulfur to hydrogen sulfide, the amount of hydrogen sulfide produced is equal on a molecular basis to the additional carbon dioxide that is given off above that of the unsulfured controls. Tests were made in nitrogen without a carbon substrate with conidia of *Neurospora sitophila*, *Monilinia fructicola*, and *Aspergillus niger* and with cells of *Saccharomyces cerevisiae*.

Effect of fungicides in miticide-fungicide dust combinations on winter carry-over of the fungus causing blackspot of roses. MCCLELLAN, W. D., EDGAR A. TAYLOR, AND FLOYD F. SMITH. The amounts of blackspot (caused by *Diplocarpon rosae*) in the spring of 1955 reflected the effectiveness of fungicidal treatments given rose plants in 120 plots of 16 plants each (5 varieties per plot) in 1954. Each fungicide was used alone and with Aramite, ovotran, and malathion. Blackspot severity indices on the susceptible variety Golden Masterpiece in September, 1954, and in June, 1955, respectively, were 1) no fungicide, 83 and 55; 2) 3.4 per cent copper from basic copper sulfate, 86 and 41; 3) as in treatment 2 plus 25 per cent sulfur, 40 and 32; 4) 7.6 per cent ferbam and 25 per cent sulfur, 44 and 27; 5) 5 per cent captan, 70 and 36; 6) 1 per cent Karathane (2-(1-methylheptyl)-4,6-dinitrophenyl crotonate), 85 and 54; and 7) 6.5 per cent zineb, 42 and 25. Similar results were obtained on another susceptible variety, Chief Seattle, given the same treatments. The amount of blackspot in 1954 and 1955, rspectively, was 1) 68 and 48, 2) 70 and 23, 3) 36 and 16, 4) 33 and 23, 5) 60 and 24, 6) 72 and 42, and 7) 34 and 20. Blackspot in 1954 devitalized the plants, and differences in flower yields occurred in May and June 1955. The mean weights in g of flowers cut from the Golden Masterpiece variety given the respective fungicidal treatments were 1) 321, 2) 356, 3) 1071, 4) 946, 5) 594, 6) 287, and 7) 979.

The use of the thulium X-ray unit in determining decay in living trees. MCNABB, HAROLD S., JR., WALLACE E. ESLYN, MILO VOSS, AND GERALD DALY. Research on the development of nondestructive techniques for the determination of decay of standing timber has yielded favorable results with the use of the thulium X-ray unit. This unit consists of a lead cylinder, 4 × 4 in. and weighing 13 lb., within which a pellet of radioactive thulium is mounted on a pivot ring. The radioactive thulium is made by radiating a 0.2-g sample of this metal in a heavy-water nuclear reactor. Usable radiations emitted by the pellet consist of 52-kev X-rays and 84-kev gamma rays. The unit is secured firmly to the bole of the tree opposite a pliable industrial film holder that is wrapped snugly to the trunk. Kodak Type K X-ray safety film, 17 × 7 in., was used in the initial studies. The energy source is pivoted from inside the lead sheath to the bark surface. Exposure trials have shown 5 minutes to be the best for the tree species being studied (*Acer saccharinum* L.) The exposed film is developed by recommended procedures and read for density differences. Decay usually is indicated by nonuniform areas on the developed negative.

Methods of inoculating wheat with the dwarf bunt fungus in the Pacific Northwest. MEINERS, J. P. Several effective techniques for inoculating wheat seed to obtain infection by the dwarf bunt fungus have been developed, through studies involving the use of germinated spores. Several methods were used to bring the germinated spores into contact with seeds and seedlings of the susceptible variety Red Bobs, and these then were incubated at 3 temperatures. The most effective methods (with the maximum smut percentages at 5°, 10°, and 15°C, respectively, indicated in parenthesis) were as follows: 1) germinated spores placed on the seed and sown in vermiculite in preparation dishes (91, 40, 24); 2) same as 1 but seed sown in sand (70, 45, 20); 3) seed placed on filter paper in the lid of inverted culture dishes containing water agar on which there were germinated spores (60, 10, 24); 4) agar carrying germinated spores removed from the culture dishes and placed directly on the seed (68, 27, 14); 5) seed pressed into agar bearing germinated spores and plate inclined so coleoptiles would grow along surface of agar (44, 25, 62); and 6) germinated seed (coleoptiles 1–4 mm long) placed in a water suspension of germinated spores and evacuated with water aspirator for 5 minutes (59, 50, 54).

Extension of the known grass host range of Tilletia caries by inoculation. MEINERS, J. P., AND J. T. WALDHER. In studies in the Pacific Northwest, the known grass host range of *Tilletia caries* was extended to include an additional 22 species representing 8 genera and 3 tribes by inoculation studies with 10 physiologic races. Spore suspensions in water were used to inoculate, by partial vacuum, 124 accessions of grasses representing 73 species, 15 genera, and 5 tribes. Infection occurred on 31 species among which were 23 in the tribe *Hordeae*, 6 in the tribe *Festuceae*, and 2 in the tribe *Aveneae*. The hosts established by this study for the first time are the following: *Agropyron amurense*, *A. ciliare* var. *subsecundum*, *A. dasystachyum*, *A. desertorum*, *A. intermedium*, *A. riparium*, *A.*

sibiricum, Arrhenatherum elatius, Bromus erectus, B. marginatus, B. tomentellus, Dactylis glomerata, Elymus canadensis, E. glaucus, E. giganteus, E. junceus, E. sibiricus, E. triticoides, Festuca idahoensis, F. ovina, Hordeum jubatum var. *caespitosum,* and *Koeleria cristata.*

A bacterial leaf rot of philodendron. MILLER, H. N. A bacterial soft rot of the leaves and petioles of certain philodendron species has been observed in commercial nurseries in Florida for the past 4 years. The disease first appears as small irregular water-soaked areas on the leaf blade. During periods of high humidity and high temperatures, development of the disease is rapid. Large areas of the leaf, or the entire leaf, are affected. Large water-filled blisters occur, followed by collapse of the leaf into a slimy mush. Leaf petioles may also become infected, resulting in their rapid and complete collapse. The crowns and roots of the plants are not attacked. The disease is most severe on the large-leafed philodendron. Infection rarely occurs naturally on *Philodendron oxycardium* Schott. In all active stages of the disease, numerous bacteria are present in the infected tissue. A number of pure-culture isolates were obtained from infected plants. These proved upon inoculation to be pathogenic. The bacteria are gram negative rods, form grayish-white glistening colonies, have perithrichic flagella, and have the ability to rot many vegetables. A member of the genus *Erwinia,* this organism appears to differ in several characters from the described species of *Erwinia.* Specific identification is being studied. Control of the disease has been obtained by spraying with Agri-mycin 100 (22.2 per cent streptomycin and 2.2 per cent oxytetracycline) formulation at the rate of 200 ppm.

Open calyx tubes as a factor contributing to carpel rots of apples. MILLER, P. M. Discolored carpels of Wagener apples have been found sporadically in 1 orchard in past years and only in this variety, suggesting a varietal characteristic that in some environments leads to disease. Calyx tubes of affected apples often remained open into the carpels. Fusarium, Botrytis, Alternaria, and other fungi isolated from affected carpels grew freely and produced discoloring when injected into normal carpels. Red Delicious apples with open calyx tubes showed carpel rots. In immature apples, fungi were found entering carpels through long calyx tubes. Many materials, including common insecticides and fungicides, produced discoloration when injected into normal carpels. This was particularly true of those materials with wetting properties. A wetting agent solution entered a carpel in 20 minutes through an opening less than 25 μ in diameter. Thus open calyx tubes may provide entrance for fungi or for spray materials that may then cause injury to the carpels. Any variety of apple with long calyx tubes may develop carpel injury when conditions prevent tube closure.

Hot water treatment of fungi from strawberry roots. MILLER, P. M., AND E. M. STODDARD. Since hot water treatment has been shown to be beneficial in freeing dormant strawberry plants of nematodes, the effect of these treatments on fungi on such plants was determined. Isolates of *Fusarium* sp., *Rhizoctonia* sp., and *Verticillium albo-atrum* obtained from strawberry plants were grown on agar slants and exposed from 1 to 7 minutes to various temperatures. Fusarium was unaffected by 5 minutes at 129° F, a treatment injurious to plants. Rhizoctonia was killed by 1-minute exposure to 125° F, a treatment noninjurious to plants. *V. albo-atrum* appeared intermediate between Fusarium and Rhizoctonia in resistance to treatment, since 4 minutes' exposure to 122° or above killed it, but it was unaffected by 1 minute at 140° F. Rhizoctonia, when grown on sterilized sections of tomato stems and covered with water during the treatment, was killed at treatments above 1 minute at 115° F. At time of treatment all fungi were in the mycelial stage.

Separation of line pattern virus from sour cherry yellows, necrotic ring spot, and prune dwarf viruses with Abundance plum. MOORE, J. DUAIN, AND H. R. CAMERON. During February and March, 1953, inoculations were made in the greenhouse to Italian prune, Montmorency cherry, Scout apricot, and Abundance and Burbank plums with chip buds from some 25 sour cherry sources that were shown by previous experiments to be infected with 1 or more stone fruit viruses, including those that incite sour cherry yellows, necrotic ring spot, and prune dwarf. In June, 1953, buds from each tree inoculated during the winter were used to inoculate Italian prune and Montmorency to determine if any virus separations had occurred. Cherry yellows, necrotic ring spot, and prune dwarf viruses were transmitted through apricot, prune, and cherry but not through either plum variety. There has been no evidence that any virus was transmitted through the Burbank plum, but in 1955 line pattern symptoms were produced on Italian prune inoculated with buds from certain Abundance plum trees. Line pattern virus was transmitted from 6 of the original sour cherry sources, which included material from Oregon, Michigan, Canada, and Wisconsin. Thus far in these experiments, line pattern symptoms have been expressed only on Italian prune inoculated with Abundance buds or on Abundance shoots growing on Italian prune thus inoculated.

A Dermea disease of dill. NEERGAARD, PAUL, ABD EL KADER, M. EL ZARKA, AND WILLIAM C. SNYDER. A blight of maturing seed plants of dill (*Anethum graveolens*) was observed for the first time in Denmark in 1954, where it destroyed a small planting. All above-ground parts, including the seed, showed brown, superficial, diffuse lesions that eventually resulted in premature death of the plants. The disease in some respects resembled an anthracnose. Isolations from stems, leaves, and seeds, consistently yielded a fungus with Fusarium-like conidia. The fungus has been determined to be the imperfect stage of a Dermea. Apothecia have been obtained on the infected dill stems, after incubation, and also in pure cultures derived both from single-conidium and single-ascospore cultures. The fungus is, therefore, homothallic. Healthy dill plants, when inoculated in the greenhouse by spraying them with a spore suspension, developed a disease similar to that observed in the field, especially as the plants approached maturity under favorable environmental conditions for infection. Although the seed used for the original planting has been shown free from the fungus, it seems apparent from the abundance of fungus on such seeds as were produced, that the fungus is potentially seed-borne. It also seems apparent that inoculum for the diseased field planting came from a source other than dill.

Transmission of factors for urediospore color in Puccinia graminis tritici by means of exchange of nuclei between vegetative hyphae. NELSON, R. R. Studies were made to determine whether factors for urediospore color could be transferred between biotypes of *Puccinia graminis tritici* by means of nuclear exchange between vegetative hyphae. Reddish-brown urediospores of race 11 and grayish-brown urediospores of race 121 of *P. graminis tritici* were mixed and used to inoculate Little Club wheat, susceptible to both races, and Vernal emmer, resistant to race 11 and susceptible to race 121. From 1 of these inoculations, an orange biotype virulent on both varieties was produced. Six single-uredium isolates were obtained from the orange biotype, and after 7 uredial generations all of the isolates had produced grayish-brown and reddish-brown dissociants. The grayish-brown dissociants were studied on the differential varieties. Thirty were intermediate in pathogenicity between races 11 and 121, and 2 exceeded both races in pathogenicity. After 10 uredial generations, orange isolates were obtained that did not dissociate further during 5 additional uredial generations. About 1 per cent of the urediospores of the 6 orange isolates were trinucleate, when examined after the fourth generation. Orange isolates continued to produce trinucleate spores as long as the isolates dissociated. The original biotypes and dissociants had only binucleate urediospores and were stable. Urediospores of stable orange biotypes also were binucleate.

Maintenance of field-resistance to Phytophthora infestans in potato selections. NIEDERHAUSER, JOHN S. AND JAVIER CERVANTES. Since 1953, over 20,000 clonal lines of potatoes from many parts of the world have been exposed to late blight in the field at Toluca, Mexico. Epiphytotic conditions have prevailed each year, and the field population of *P. infestans* includes at least 13 distinct races. Approximately 150 selections that show good field resistance and that are fair to good in commercial acceptability have been made. No clone yet tested has been immune to blight in the field at Toluca. To date, the field resistance of each of the selections has been maintained at the same level each year. Field resistance in some clones is independent of the hypersensitive or "major gene" resistance, which by itself has been of little value in the Toluca tests. Clones Ac 25953 and Ac 25949 are valuable parents that confer high levels of field resistance.

Evaluation of Irish potatoes for resistance to Pseudomonas solanacearum. NIELSEN, L. W. The evaluation of potatoes for resistance to *Pseudomonas solanacearum* is difficult under field conditions. Greenhouse inoculations were made in search of a reliable procedure for evaluating resistance under controlled conditions. Sixteen selections, including Prisca (resistant) and Irish Cobbler (susceptible), were evaluated in the greenhouse and field. In the greenhouse, single-stem plants were grown to bud or early bloom stage in 4-in. pots at 24° C, then transferred to a suitable temperature for inoculation. Eight to 10 plants of each selection were inoculated by pouring 10 ml of dilute bacterial suspension into each of 2 radial cuts in the soil made at the periphery of the pot. Disease symptoms were read 14 days later by the index method. In the field, seed-pieces of selections were planted in replicated pots in infested soil. Planting was in late March in order to delay maturity until June and early July. After wilt appeared, infected hills were counted at 7- or 14-day intervals. The data from the tests were statistically analyzed, and the correlation coefficient between disease indices (greenhouse) and percentage diseased hills (field) for the 16 selections was highly significant.

Evidence of resistance in sweet potato to the internal cork virus. NIELSEN, L. W. Forty-five sweet potato entries, including varieties, selections, and breeding stocks, were studied for their reaction to the internal cork virus for 3 or 4 years. Each year, bedding roots were core-graft inoculated with virus-infected tissue, and sprouts from these roots were used for propagation. Harvested roots were stored at 70°–80° F for 5–6 months before slicing and examining for internal cork symptoms. Thirty-five entries developed cork symptoms, and the range of corky roots varied from 0.7 to 92.5, with Porto Rico most susceptible. Eleven entries, including Nancy Hall, developed no lesions. To confirm or determine the presence of virus in roots having few or no symptoms, cores of tissue from these entries were grafted into cork-free Porto Rico roots, which were then incubated and examined as described. Tissue from all selections with few symptoms and 7 of those free of symptoms, including Nancy Hall, caused symptom development in Porto Rico roots. No symptoms developed when tissue from Hm 15, Hm 2, Hm 22, or NC 164 was used. This wide range of cork symptom development indicates that a number of genetic factors affect virus multiplication and symptom development in sweet potato.

Factors affecting stripe rust of wheat in Colombia. ORJUELA, J. *Puccinia glumarum* is the most destructive rust fungus of wheat in Colombia. Altitude and temperature are closely correlated with losses from stripe rust, although "intensity of infection" (an arbitrary mathematical expression for prevalence, severity, and reaction) may vary over relatively short distances at the same elevation. Wheats grown at approximately 3000 m and at 10°C are more severely infected and damaged than wheats grown at approximately 2000 m and at 18°C. During more than 5 years, no less than 10 field nurseries, located at different places in the country, have shown that varieties differ in reactions to stripe rust in different geographic areas, which is circumstantial evidence that physiologic races of *P. glumarum* exist in Colombia. Generally, all parts of a plant of a given variety have the same disease reaction. In varieties such as Menkemen, however, rust is severe on leaves and awns but not on the glumes, and the grain is seldom damaged. In other varieties, such as Kenya Governor, rust is light on leaves but the glumes are severely rusted and 50 per cent of the crop may be lost because kernels are shrivelled. Partial infection of the glumes is less injurious to kernels than complete infection.

Antagonistic and synergistic associations of two citrus-rotting fungi on agar media and in host tissue. OSTERAAS, A. JEAN. In studies on the influence of different substrates on the virulence of 2 pathogens of citrus fruit, *Penicillium digitatum* and an unidentified fungus whose characteristics resemble that of *Diplodia natalensis*, various associations of these fungi in mixed cultures were observed. Inoculations of lemons and limes with either of the pathogens resulted in considerable fruit deterioration, whereas inoculations involving both fungi together caused much less rot. In contrast, inoculations of navel oranges with both fungi together resulted in greater fruit deterioration than resulted from inoculations with either of the pathogens alone. In mixed cultures, colonies of these fungi on agar media were antagonistic, indifferent, or synergistic toward the growth of each other depending upon the composition of the original culture medium.

Soybeans as a green manure crop for the prevention of potato scab. OSWALD, JOHN W., AND O. A. LORENZ. In Kern County, California, a field study was initiated in 1949 to investigate the build-up of the potato scab fungus, *Streptomyces scabies*, under different rotations. Four rotations involved potatoes each year. One of these had no cover crop, and the other 3 had either soybeans, fall peas, or fall barley green manure cover crops between each potato crop. In the first crop, all rotations yielded tubers that were all marketable, and scab indices (average percentage of tuber surface covered with scab) were uniform but low (0.17, 0.35, 0.41, and 0.14). By the fifth crop, scab index for the check (no cover crop) was 2.34; for the fall pea cover, 2.10; for the fall barley cover, 2.89; and for the soybean cover, 0.71. After the seventh consecutive potato crop, the check index was 11.83, with only 48 per cent of the tubers marketable, and that for fall peas was approximately the same. The seventh potato crop with annual soybean green manure crops had a scab index of only 0.39, and all tubers were marketable. The fall barley cover increased the infestation: the scab index was 17.57 and only 27 per cent of the tubers were marketable.

Allyl alcohol as a soil fungicide. OVERMAN, AMEGDA J., AND D. S. BURGIS. Allyl alcohol (AA) has been tested in seedbed experiments for the past 12 crop seasons and has proved a superior fungicide. Drenches at the rate of 25 gal. of the alcohol in 5500 gal. of water per acre were effective in controlling *Pellicularia* spp., *Pythium* spp., and *Fusarium* spp. in vegetable seedbeds planted on Leon fine sand. In all trials to date, the earliest seeding after treatment has been on the seventh day, and the crops have shown no indication of damage by the chemical. Weekly dilution platings of soil samples were made on peptone-agar to follow the effects of the various treatments on populations of common soil fungi. Plots treated with AA have consistently shown a significant increase in *Trichoderma spp.* by the seventh day after treatment. The surplus of Trichoderma remains through the seedbed period in the AA plots. This is in sharp contrast with plots treated (some actually sterilized) with other materials, where resurgence of normal levels of damaging fungi occurs in a few weeks. It appears that extra activity of Trichoderma in plots treated with AA accounts for the superior effectiveness of the chemical.

Effects of fungicides on levels of adenosine polyphosphates, inorganic phosphate, and phosphate esters contained in fungus spores. OWENS, ROBERT G. Asexual spores of *Neurospora sitophila* and other fungi were assayed by established techniques for changes in levels of adenosine polyphosphates, inorganic phosphates, and phosphate esters. Assays were carried out also on comparable quantities of spores incubated under aerobic conditions for 12–16 hours in the presence and absence of fungicides. The results indicated that adenosine diphosphates and triphosphates were present in about equal concentrations before incubation of conidia and remained at a fairly constant level during incubation whether or not fungicides were present. Inorganic phosphate levels were higher than those of adenosine polyphosphates but decreased upon incubation. Assays on phosphate esters, spore ash, and leachings from the spores indicated that the inorganic phosphate was incorporated into organic molecules. Incubation of spores in the presence of elemental sulfur, dithiocarbamates, quinones, imidazoline, or captan at concentrations toxic to spores, however, inhibited inorganic phosphate assimilation and, in some cases, increased the amount of phosphate present in the inorganic form. The probable mechanisms of inhibition and the interrelationships between growth and inorganic phosphate assimilation are discussed.

Nematodes affecting corn in Florida, Alabama, Maryland, and Wisconsin. PERRY, VERNON G. Several nematode species, endoparasites and ectoparasites, are recognized parasites of corn. Most field corn and sweet corn varieties are known to be susceptible hosts of meadow nematodes (*Pratylenchus* spp.), the stubby root nematode (*Trichodorus* sp.), the sting nematode (*Belonolaimus gracilis*), dagger nematodes (*Xiphinema* spp.), and a spiral nematode (*Helicotylenchus* sp.). Examinations in Florida, Alabama, Maryland, and Wisconsin indicate that 1 or more of the types mentioned, plus many others, are common and numerous within each area of each state where the samples were collected. Stubby root and meadow nematodes are considered most damaging in Florida and Alabama, with many other species involved. Limited examinations in Maryland indicate that meadow nematodes are of major importance on corn but that the stubby root nematode is also involved. Meadow nematodes, dagger nematodes, and a spiral nematode have been observed as causing damage in Wisconsin, but the damage is not considered so severe as in the southern states. The growth of sweet corn was substantially increased by the use of commercial nematocides in a replicated plot experiment at Madison, Wisconsin, in 1955. The frequent finding of many nematodes of unknown pathogenicity associated with stunted corn emphasizes the need for considerable research on nematode diseases of corn.

Photoperiod and light intensity in relation to multiplication of tobacco mosaic virus in tobacco. POUND, GLENN S., AND JOHN B. BANCROFT. Photoperiods of 12 and 16 hours increased concentration of TMV in inoculated and systemically infected leaves of tobacco 4 days after inoculation over photoperiods of 8 and 4 hours. Subsequent assays from tip leaves and from whole plants showed an orderly shift in concentration pattern. For instance, concentration in tip leaves increased with a decrease in day length at 4 and 18 days but increased with an increase in day length at 7 and 32 days after inoculation. High light intensity generally favored virus multiplication in the inoculated leaves and initially in the tip leaves. With increased time, an orderly shift in concentration pattern similar to that for photoperiod was observed. In inoculated tobacco leaf discs cultured on water agar at 29°C at a day length of 16 hours and at a light intensity of 3200 foot-candles, TMV multiplication for 96 hours was less than in discs kept in total darkness. Long days of diffuse light were more favorable for virus multiplication in disc tissues than short days with intense light.

Heterothallism in Erysiphe graminis tritici. POWERS, HARRY R., JR., AND J. G. MOSEMAN. Tests of 20 cultures of *Erysiphe graminis tritici* Em. Marchal, each originating from a single ascospore, demonstrated that this organism is heterothallic. The cultures were grown, both separately and in combinations of 2 at a time, on isolated plants of a susceptible wheat variety. In no case were cleistothecia found on any of the 20 plants inoculated with only 1 culture. Abundant cleistothecia were produced, however, in 14 of 34 combinations used. Analysis of these results indicated that the 20 cultures represented at least 2 distinct sexual compatibility groups. Mating was possible between cultures originating from the same cleistothecium, as well as between cultures from different cleistothecia. The results also indicated that compatibility was not linked with pathogenicity. Some cultures, which gave identical pathogenic reactions on 7 differential varieties, were found to be of opposite sexual compatibility types. Other cultures, which differed in pathogenicity, were identical in mating potential. Similar studies using *E. graminis hordei* Em. Marchal are in progress. The results of these tests are incomplete; however, there are indications that this organism also may be heterothallic.

Organic chemicals containing chlorine as seed treatments for wheat smut control. PURDY, LAURENCE H. The effectiveness of certain organic chemicals, which do not contain mercury, in controlling wheat smut by seed treatment appears to be related to the number of chlorine atoms contained in the molecule. Tests conducted in the 5 Pacific Northwest states have shown that the most effective chemical of this type for smut control was hexachlorobenzene (HCB), which contains 6 chlorine atoms. As the chlorine atoms become fewer on the benzene ring, the degree of smut control lessens. Thus, pentachlorobenzene (PCB) and tetrachlorobenzene (TCB) were less effective than HCB, in that order. The substitution of 1 nitro group for 1 chlorine atom also reduces the effectiveness of the chemical for wheat smut control. Pentachloronitrobenzene (PCNB) was less effective than HCB and was only slightly more effective than PCB. Tetrachloronitrobenzene (TCNB) was more effective than TCB in degree of control, but both were inferior to HCB, PCB, or PCNB. Hexachloroethane effectively inhibited spore germination on water agar in sealed petri plates, but as a seed treatment did not control smut.

Vapor action of some seed-treatment fungicides used for wheat smut control. PURDY, LAURENCE H. Tests were conducted in the laboratory, greenhouse, and field with 3 fungicides—Anticarie (40 per cent hexachlorobenzene), Ceresan M (7.7 per cent *N*-(ethylmercuri)-*p*-toluenesulfonanilide), and Panogen 15 (2.2 per cent cyano(methylmercuri)guanidine)—to determine the effectiveness of vapor action in inhibiting spore germination on water agar and in controlling wheat smut. The fungicides were placed in small vials that were placed either in petri plates containing water agar seeded with spores or in plates containing only inoculated seed of Elgin winter wheat or Red Bobs spring wheat. All plates were sealed with rubber band seals and were held at 15°C until spore germination was counted or the seed was planted. Only Anticarie and Panogen inhibited spore germination on water agar by vapor action. Germination averaged over 50 per cent in the check and Ceresan M plates and 2 and 0 per cent, respectively, in the Panogen and Anticarie plates. Only Panogen controlled smut by vapor action, reducing the incidence from above 75 per cent (in the checks) to less than 1 per cent. Control by the other materials apparently depends on direct contact.

Techniques for studying varietal response to Septoria leaf blotch of wheat. RENFRO, B. L., AND H. C. YOUNG, JR. Studies were made on factors that influenced infection by *Septoria tritici* and the reaction of wheat varieties to this fungus. In the greenhouse, the most effective way to produce an epidemic was to strip the leaves between fingers that had been dipped in inoculum, place the plants in a moist chamber for 3–4 days, and 8 days later rewet them

for 24 hours. Field epidemics were produced by spraying the plants in the jointing stage with a mixture of conidial and mycelial suspensions of isolates derived from several wheat varieties grown at different locations in Oklahoma. Optimum conditions for good infection are the presence of free moisture on the foliage for about 35 hours and high humidity for 2 or more days. Infection was inhibited when free moisture was not available for at least 15 hours or when the minimum temperature was 7°C or below during a 2-day postinoculation period. High humidity is also conducive to pycnidial formation, and the optimum temperature for infection is about 21°C. Of 17 winter wheat varieties tested for resistance, Red Chief and Nabob were very resistant to all isolates, whereas Westar, Triumph, Early Blackhull, and Wichita were the most susceptible.

The effect of various fungicides on apple pollination and fruit set. Rich, Avery E., and James D. Bilbruck. Apple scab is usually a problem during bloom in the Northeast, but little information is available concerning which fungicides are safe to use on trees in bloom. Pollen germination was greatly inhibited when pollen was immersed in certain fungicidal sprays at concentrations as low as ¼ field-strength. Captan, glyodin, ferbam, and dichlone, at ½ lb., ⅜ pt., ½ lb. and ⅛ lb., respectively, almost completely inhibited pollen germination, whereas sulfur had very little effect. Blossoms were sprayed with these fungicides at field strength in the orchard. Pollen was used from these blooms to pollinate unsprayed flowers, and unsprayed pollen was used to pollinate the blooms sprayed with these fungicides. None of the fungicides tested adversely affected pollination or fruit set. These results show that pollen grains germinate poorly if at all when immersed in a weak fungicide solution of captan, glyodin, ferbam, or dichlone, whereas they germinate satisfactorily when sprayed with these fungicides and the spray is allowed to dry. It is evident that the first method of testing is too severe for use in determining which fungicides are safe to use in bloom.

Differential action of chelators on growth and spore germination of Monilinia fructicola. Rich, Saul. Chelators are generally not very toxic to spores of *Monilinia fructicola.* Those that are toxic to spores are toxic to mycelium Several chelators such as dimethylglyoxime and α-furildioxime are not toxic to spores but are quite toxic to mycelial growth. Chelators such as 2-amino-2-methyl-1-propanol and chrysoidine Y are not toxic to either spores or mycelium, but they may increase sporulation. Spores of *M. fructicola* do not require an external supply of metallic micronutrients in order to germinate. Therefore, chelators that are toxic to spores must act 1) to interfere with their internal metals or 2) by a mechanism other than chelation. Chelators toxic to mycelium and not to spores must act by making the metals in the medium unavailable to the mycelium. These chelators apparently are either not sorbed by the spores or are unable to interfere with internal metals. Nontoxic chelators that enhance sporulation may aid the pentration of metals into the mycelium where they release the metals to the organism. The metal may be released 1) by biological degradation of the chelator or 2) through the action of naturally occurring chelators within the fungus that may combine with the metal and remove it from the synthetic chelator. If the latter phenomenon occurs, the chelator thus freed must be nontoxic to the organism.

Meadow nematode and its relation to decline of strawberry plants in Arkansas. Riggs, R. D., D. A. Slack, and J. P. Fulton. Meadow nematode, *Pratylenchus coffeae* (Zimm.) Sher & Allen, was associated with strawberry black root. Highest populations were recovered from roots of plants growing in relatively heavy soils. Studies of seasonal variation of populations of *P. coffeae* in strawberry roots showed 1) numbers less than 1000 per g of root during winter and through March, 2) an increase in numbers during April and May to a maximum of 14,000 per g of root, and 3) a decrease in numbers during midsummer and fall. In the greenhouse, strawberry plants growing in sterilized soil were inoculated with *P. coffeae.* After 6 weeks, an average of 140 specimens were recovered from roots as compared to 50 used for inoculation. In soil temperature studies, build-up of population increased with each increase of temperature from 75° to 92°F.

Use of a detached-leaf technique for testing leguminous forage plants for resistance to foliage diseases. Roberts, D. A. Detached leaves of several leguminous forage plants will remain green for at least 10 days when floated on dilute sucrose solutions. In 3 experiments, detached leaves of alfalfa, red clover, and birdsfoot trefoil were floated on 2 per cent sucrose solutions in Syracuse watch glasses and inoculated with finely chopped mycelium and spores of leaf-spotting fungi. Each fungus was allowed to grow on potato-dextrose agar in Petri dishes until mycelial mats covered the surface of the culture medium. The contents of each dish were placed in 100 ml of water and chopped in a Waring Blendor. The material was strained through 2 layers of cheesecloth. Inoculum of *Ascochyta imperfecta* Pk. was atomized onto detached alfalfa leaves, and typical leaf lesions developed within 4 days. Within 1 week after inoculation, diagnostic symptoms were produced by *Stemphylium sarcinaeforme* (Cav.) Wiltsh. on red clover leaves and by *Stemphylium loti* Graham on birdsfoot trefoil leaves. Although this method does not provide a test for disease escape mechanisms that might obtain under field conditions, it does make possible rapid screening of individual plants for disease resistance in a minimum of space without sacrifice of entire plants.

Influence of alfalfa mosaic virus infection upon winter hardiness of Ladino clover. Roberts, D. A. Kreitlow and Price suggested that winter hardiness of Ladino clover might be reduced as a consequence of infection by the yellow patch virus, *Marmor medicaginis* Holmes var. *ladino* Kreitlow & Price. Ladino clover plants growing in 4-in. pots were mechanically inoculated with alfalfa mosaic virus from tobacco plants that had been infected for 2 weeks. Inoculated plants were kept in a greenhouse at 65–70°F for 3 weeks. After they had become systemically infected, as determined by infectivity tests in which Bountiful beans were used as indicator plants, 13 infected and 17 comparable healthy plants were "hardened" for 2 weeks by daily treatment of 8 hours light at 50°F and 16 hours darkness at 40°F. Afterward, all plants were kept for 2.5 hours at 0°F, then for 1 week in the light at 50°F before being moved to the greenhouse. All virus-infected plants died, whereas only 5 healthy plants died. When the experiment was repeated, none of the 25 infected plants survived the cold treatment, but 22 of 40 healthy plants remained alive. Apparently alfalfa mosaic virus infection reduced cold hardiness of Ladino clover, probably as a result of impaired carbohydrate synthesis and storage in diseased plants.

Exclusion of Puccinia rubigo-vera f. sp. tritici by stomata of wheat stems and leaf sheaths. Romig, Robert W., and Ralph M. Caldwell. Infection by *Puccinia rubigo-vera* f. sp. *tritici* rarely occurs on sheaths and culms at anthesis, but as the plants ripen, these parts may become infected. Penetration of stomata was studied on strips of fixed and stained epidermis. The ability of appressoria to effect penetration of the different parts was associated with the degree of infection. At anthesis, the stomata of blades and of the inner epidermis of sheaths were readily penetrated. Low percentages of appressoria effected penetration of the outer epidermis of sheaths whereas peduncles were rarely penetrated. As plants ripened, high percentages of appressoria effected penetration of peduncles and the outer epidermis of sheaths. Penetration of dead peduncles also occurred readily. Abnormal lobing of appressoria and the formation of the infection apparatus on the surface were associated with resistance to penetration. Peduncle

injuries at anthesis resulted in infection adjacent to the injuries. The only plant character found associated with exclusion was the thicker walls of the stomatal cells of sheaths and peduncles. Since senescent peduncles and sheaths were readily penetrated, and infection occurred near injuries, stomatal function, as well as structure, may be involved in exclusion.

Rehydration injury of dried urediospores of Puccinia graminis var. tritici. ROWELL, J. B. An injurious effect has been observed during the rehydration of dried urediospores of *Puccinia graminis* var. *tritici*. Few old air-dried or lyophilized urediospores germinate when transferred directly to water, but germination is improved if the spores are first dispersed in a drop of light petrolatum, U.S.P. (e.g. 10 and 40 per cent for direct and oil transfers, respectively). When dried urediospores alone or urediospores dispersed in oil are placed on nonpolar films, they remain in place when covered with distilled water, and the effect of submersion in water is readily observed by microscopic examination. Prior to water contact, the urediospore is shriveled. When covered with water, the wall immediately returns to its original shape whereas the protoplast oftentimes remains contracted into a dense mass separated from the urediospore wall. Many of these spores fail to germinate although the protoplast may swell gradually to fill the wall volume within 20 minutes after the addition of water. However, spores dispersed in oil retain the shriveled appearance for a time after the addition of water. Over a 20-minute period, the spores gradually swell to the original morphology with the wall and protoplast remaining intact. Apparently the separation of wall and protoplast on direct contact of dried urediospores with water is due to differential rates of rehydration. The resulting injuries may be lethal to the spore.

Forms and races of Puccinia helianthi. SACKSTON, W. E. Rust collections from 1 annual and 4 perennial wild species of *Helianthus* in Manitoba differed in pathogenicity in cross-inoculation tests. Teliospores from 1 perennial species were used to infect plants of the same species and cultivated sunflowers. On the 2 hosts, urediospore cultures from aeciospores produced on the respective hosts infected only the species from which they were obtained. Recently developed rust-resistant sunflower selections were used to differentiate races of the pathogen. Seven cultures of the rust fungus from cultivated sunflowers collected in 1954, 6 in Manitoba and 1 in southern Chile, fell into 3 groups based on seedling reactions. Four cultures from susceptible varieties, including the Chilean one, attacked only susceptible varieties. Two cultures from plant-breeding material induced "susceptible" reactions in seedlings with the "953-88" factor for resistance. One culture, from a susceptible variety grown outside the main sunflower area in Manitoba, attacked 1 of 2 selections with the "953-102" factor for resistance but not lines derived from "953-88".

Rust as a factor in sunflower production. SACKSTON, W. E., and ERIC D. PUTT. Rust has caused heavy losses in yield of sunflowers in Manitoba and has caused sharp reductions in sunflower acreage. In experiments on rust control, various chemicals were applied to sunflower plots prior to inoculation and several days after inoculation. None of the chemicals tested was effective as an eradicant. Plots treated with zineb, the best of the protectants tested, yielded twice as much seed as did unprotected check plots. The mechanical difficulty of treating tall plants, and the cost for a relatively low cash value crop, make chemical control of rust impractical for all but valuable seed plots of sunflowers. Inoculated and noninoculated newly developed rust-resistant varieties and susceptible varieties were grown in field plots. Seed yields of the inoculated and noninoculated resistant varieties were similar and much higher than those of susceptible varieties. Inoculation reduced the yield of susceptible varieties by ⅓ to ½. When the same varieties were grown in a rust-free area, the rust susceptible varieties yielded as much as or more than did the resistant ones.

Bioassay of the translocated fungicide, 2-pyridinethiol-1-oxide, in cucumber seedlings. SANDER, EVAMARIE, AND PATRICIA ALLISON. Inhibition of germination of conidia of *Monilinia fructicola* was used in bioassay of cucumber plants that had been treated with 2-pyridinethiol-1-oxide. At intervals after the primary leaf was dipped in an 80-ppm aqueous solution of the chemical, tissue homogenates were made of various plant parts and centrifuged. The supernatant extracts were then tested for inhibition. Known amounts of chemical were added to similar extracts from the same parts of untreated plants in each experiment so that the concentration in treated plants could be deduced. The chemical not only enters the plant but is rapidly translocated from the primary leaf. A concentration of 80 ppm was detected in extracts of roots 12 hours after leaf dipping. The chemical was present in lower concentrations elsewhere. Concentrations were lower 76 hours after treatment than 12 hours after treatment. The chemical was evidently inactivated in extracts of young shoots and cotyledons, since known low concentrations could not be assayed in extracts from these tissues but were detectible in extracts of other tissues.

The effect of light quality on the development of races 21 and 34 of Puccinia graminis var. tritici. SANTIAGO, J. CARVALHO. Thirteen wheat stem rust differential varieties were inoculated with race 21 or 34 of *Puccinia graminis* var. *tritici* and grown in light of different predominating wave lengths transmitted by colored cellophanes: red (90 per cent 6600 A), amber (92 per cent 5800–6800 A), green (43 per cent 5200 A), and blue (56 per cent 4500 A). Controls were under transparent colorless cellophane and also in natural greenhouse light. Mean temperature in all locations was 73°F. Daily light intensity averaged 2100 foot-candles for controls and 580–600 under colored cellophanes. Race 34 developed normally in all lights. A monosporic culture of race 21 produced 20–40 uredia per leaf in all varieties in the controls. At 4500–5200 A, only 2–5 uredia developed on Marquis, whereas Kota had 2–8 uredia and 10–20 flecks per leaf. At 5200 A, Spelmar and Arnautka had 20–40 infections per leaf but the majority were flecks that developed no further when plants were transferred to normal light after 15 days. In concurrent experiments, when natural light was reduced to 600 foot-candles or the day length to 4–8 hours, number of infections was not reduced and the fungus sporulated consistently.

The cause of wilting in Verticillium-infected tomato plants. SCHEFFER, R. P., S. S. GOTHOSKAR, C. F. PIERSON, AND R. P. COLLINS. Plants infected with *Verticillium albo-atrum* often wilted partially during the day and recovered at night when transpiration was low, suggesting that wilt resulted from poor water conduction. This theory was supported by data on transpiration, which showed decreased water loss accompanying symptom expression. It was further supported by dye-conduction experiments, which showed xylem vessel blockage in petioles and stems. Culture fluids of Verticillium contained a heat-labile vascular-browning factor. Alkali titration assays with these fluids, using pectin solutions as substrates, showed that very little pectin methyl esterase (PE) was present. Iodine titration of reducing groups and viscosity measurements showed the presence of polygalacturonase. When highly esterified pectin solution was used as substrate, there was very slight reduction in viscosity following incubation with culture fluids, indicating that depolymerase (DP) was not present. Pectic enzymes are thought to cause wilt by breaking down pectins in xylem walls, thus either increasing viscosity of vascular fluids or forming gel-like blocks. Vascular browning may result indirectly from cellular disorganization. Verticillium differed from Fusarium in that the latter produced PE and DP.

Studies on the dissemination and control of the Moko disease of bananas. SEQUEIRA, LUIS. Bacterial wilt of bananas, caused by *Pseudomonas solanacearum* and known as Moko disease, is a serious problem. Different isolates

of the causal organism exhibit considerable variation in morphological and physiological characteristics. When an infested tool was used, 84.9 per cent of all plants pruned showed symptoms of Moko disease 9 weeks after pruning, whereas none of the plants pruned with a tool disinfested with 5 per cent phenol showed signs of the disease. In experimental plots, tests were made with a sanitation program based on 2 important points: 1) disinfestation of machetes and other tools used in pruning operations, and 2) elimination of all infected mats. This program drastically reduced the spread of the disease, e.g. from 10 per cent to 0.3 per cent increase in the total number of cases during a 6-month period. The addition of D-D (1,3-dichloropropene; 1,2-dichloropropane), formaldehyde, and large amounts of urea to the sites of infected plants did not permit replanting without a fallowing period. When infested abandoned land was plowed several times during the dry season and then replanted, there was a very low incidence of disease 10 months after replanting, indicating that the primary requirement for the elimination of the Moko bacterium from soil is that the moisture content be dropped to a level detrimental to the pathogen.

Modified paper-disk method for laboratory fungicidal bioassay. SHARVELLE, E. G., AND E. N. PELLETIER. Existing methods for fungicidal bioassay impose certain limitations with respect to spore requirements and physical properties of the test chemical. A modified paper-disk method was developed to avoid such limitations. Filter paper bioassay disks, 12.7 mm in diameter, are sterilized, immersed in solutions or suspensions of test chemicals of known concentration, and then drained. The disks are seeded with a calibrated suspension of the test fungus by atomizing or by applying with a dropping pipette. Three replicate disks are placed on agar medium plates and the plates incubated. Observation of a concentration series of test chemical, at regular time intervals, permits determination of minimum inhibition concentration. Growth measurements from the periphery of treated and untreated disks provide dosage response data. For testing volatile materials, the sterilized disks are first impregnated with the test fungus suspension and then transferred to the surface of a sterilized glass plate. The plate is then placed in a gas-tight bottle of known capacity and liquid volatile chemical added to a pad in the bottle-lid. Solid volatile materials in weighted amounts may be placed in open vials in the bottle. At the conclusion of the treatment period, the disks are transferred to the surface of agar medium. Periodic observation of air-dilution series permits determination of inhibition concentrations.

Effective inoculation of aspen with Hypoxylon pruinatum. SHEA, K. R., AND J. E. KUNTZ. In breeding disease-resistant poplars, satisfactory techniques were needed for testing resistance to Hypoxylon canker. Different inoculation methods were tried on 720 native aspens. Inocula were prepared by culturing *Hypoxylon pruinatum* (Kl.) Cke. on the following media: 100 per cent bran, potato-cerelose agar, and a 3:1 oat:wheat mixture. Either culture fragments or spore suspensions prepared from natural cankers were inserted into a vertical chisel cut in the bole of each tree. Following inoculation, wounds either were left open or were covered. As a check, a similar but noninoculated wound was made on the opposite side of the tree. After 1 year, all checks were noninfected and were callusing over. Spore suspensions injected into either exposed or covered wounds also gave negative results. Inoculation with agar cultures resulted in infection in 10 per cent of the wounds covered with moist cotton and in 32 per cent of the wounds protected with masking tape. Inoculation with bran or grain cultures gave 21 and 79 per cent infection, respectively, in exposed wounds. In wounds covered with masking tape, they gave 18 and 82 per cent infection, respectively. Thus, inoculations with oat and wheat cultures proved most effective.

A simplified method for culturing carnation cuttings for Fusarium wilt. SHURTLEFF, M. C., AND C. H. SHERWOOD. Carnation growers have long needed an easy technique for screening against Fusarium wilt (caused by *Fusarium oxysporum* f. *dianthi*) by culturing their own cuttings. Such a method has been developed. One or several 1-in. sections (including a node) were removed from the base of candidate cuttings, by means of a knife dipped in a sodium hypochlorite solution. The cut sections were dipped or soaked (up to 1 minute) in a 0.5 to 5.25 per cent sodium hypochlorite solution and placed singly in small, numbered, loosely capped, clear plastic or glass vials. The vials containing sections from a number of cuttings were put in a large container capped with aluminum foil. A relative humidity of approximately 98 per cent was maintained by means of a small amount of a saturated solution of calcium sulphate. In 5–7 days, the abundant white mycelium of Fusarium was seen growing on the surface of sections from diseased cuttings. Sections from healthy cuttings showed no mycelial growth. No differences were found when this method was compared with the more difficult, conventional technique of plating sections of cuttings on agar. This method is being developed for use in screening other plant cuttings for vascular pathogens.

Use of corn and Agrotricum hybrids for more rapid identification of three grass viruses. SILL, W. H., JR. Many varieties of corn and 12 Agrotricum (*Agropyron* × wheat) hybrids, varying from grass-like to wheat-like, have been tested for 3 years in many trials as diagnostic hosts for more rapid identification of 3 manually transmissible grass viruses: wheat streak mosaic virus (WSMV), brome mosaic virus (BMV), and barley stripe mosaic virus (BSMV). On seedling corn, WSMV caused local lesions on a few varieties and diffuse systemic infection without stunting on others. Some were immune. BMV caused severe systemic infection, usually followed by rapid top necrosis and death. BSMV caused severe systemic infection, characterized by stunting and broad yellow to white stripes, usually on the younger leaves. On the Agrotricum hybrids, the WSMV reaction varied from immunity in some grass-like types through various gradations of resistance and tolerance in intermediate types, including several that gave local lesions only and 1 in which the local lesions were sometimes followed by systemic necrosis. The wheat-like types were usually susceptible, developing systemic streak mosaic symptoms accompanied by stunting. All Agrotricums tested were susceptible to both BMV and BSMV. A severe systemic infection characterized by yellow to white mosaic and mottle with severe stunting was typical.

Effects of certain insecticides and physical barriers on field spread of pepper veinbanding mosaic virus. SIMONS, JOHN N. During the fall and spring of 1954-55, field plot trials were conducted to determine the effects of parathion and demeton on the spread of veinbanding mosaic virus of pepper. These materials were ineffective against within-field spread of virus. Use of parathion on the primary source of inoculum outside the plots caused a significant reduction in number of infected plants in the plots. Sunflowers, when used as a barrier crop between the weed source and the peppers, significantly slowed the rate of transmission. Sunflowers sprayed with demeton were only slightly better barriers than unsprayed sunflowers. Results also indicated that a low level of aphid population could cause rapid spread of virus and that a distance of 150 ft. between the source of virus and susceptible peppers was sufficient to stop transmission under cool fall and winter conditions.

Assays for resistance to cucumber mosaic. SINCLAIR, J. B. A study was made of various means of assaying cucumber progenies for resistance to common cucumber mosaic. Expression of resistance in the field was compared with controlled conditions in the greenhouse. Field trials during 5 years showed that while there was usually a reduction

in total yield of fruits of susceptible varieties, yield alone was not a reliable measure of resistance. Since the percentage and severity of mottled fruits rose steadily during the harvest season in susceptible varieties while they remained low in resistant varieties, these criteria were found to be the most reliable for judging the relative resistance of varieties and individual plants. Greenhouse assay was a useful means of measuring resistance only when carried out under relatively high light intensity and at temperatures of 24°–28°C. Even under those conditions, the difference in reaction of resistant and susceptible varieties was sometimes small, and this assay could be used reliably only as a supplement to field tests.

Life history and host range of the soybean cyst nematode. SKOTLAND, C. B. In studies on the life history of *Heterodera glycines*, roots of soybean seedlings were inoculated with second-stage larvae. After 48 hours, the roots were washed and the seedlings transplanted into nematode-free soil and incubated at 75°F. At 48-hour intervals, roots were examined for the male and female developmental stages, and the soil was examined for the various motile stages. Mature males were found at 14 days and second-generation larvae at 21 days after inoculation. These results suggest that 5 generations could be produced on a soybean crop in 1 season in North Carolina. In host range studies, 39 plant species representing 23 genera in the Leguminosae, Crucifercae, Cucurbitaceae, Solanaceae, Gramineae, Chenopodioceae, Iridaceae, and Amaryllidaceae were inoculated with second-stage larvae under greenhouse conditions. Penetration on several legumes occurred, but reproduction occurred only on the roots of annual lespedeza (*Lespedeza stipulaceae*), common vetch (*Vicia sativa*), soybeans (*Glycine max* and *G. ussurinesis*), snapbeans (*Phaseolus vulgaris*), and adzuki bean (*P. angularis*). Annual lespedeza and common vetch are new hosts for *H. glycines*.

Antagonistic action of cysteine and certain other compounds on the fungitoxicity of sodium dimethyldithiocarbamate. SMALE, BERNARD C., CARROLL E. COX, AND HUGH D. SISLER. The auxanographic technique was used to investigate the effectiveness of several amino and alpha keto acids, glutathione, and other compounds in antagonizing the toxic effect of sodium dimethyldithiocarbamate (NaDDC). With a species of *Penicillium* that is relatively resistant to NaDDC, all growth is prevented at pH 6.4 by 60 ppm of the fungicide. If cysteine or glutathione is present, growth is not prevented by NaDDC at a concentration of 380 ppm. Growth of *Glomerella cingulata* is prevented by a concentration of the fungicide of less than 0.03 ppm at pH 6.4 and pH 5.0. In the presence of cysteine, growth occurs at pH 6.4 in the presence of 0.127 ppm NaDDC and at pH 5.0 when the concentration of fungicide is 64 ppm. Dihydroxyphenylalanine, phenylalanine, and homocystine were only slightly effective at pH 6.4, whereas pyruvic, alpha ketoglutaric, and oxaloacetic acids were not effective in reducing the toxicity of NaDDC to *Glomerella cingulata*.

Virus yellows of garbanzo. SNYDER, WILLIAM C., A. O. PAULUS, AND A. H. GOLD. Field plants of garbanzo (*Cicer arietinum*) in San Diego, Ventura, Santa Barbara, Yolo, and Alameda counties of California frequently are affected by a yellows disease. As many as 50 per cent of the plants may be infected. The amount of yellows varies with the season, but the disease has been observed in the state since 1937. Symptoms consist of a general yellowing of the foliage, shortening of the internodes, often an increased stiffness and twisting of the terminal growth, and a brown internal vascular discoloration of the stem. The discoloration is confined largely to the phloem and is usually sterile. Early infection may result in death of the plant. Electron microscopy has demonstrated the presence of rods, resembling those of yellow bean mosaic virus, concentrated in the discolored phloem tissues. Juice transmissions have yielded strains of yellow bean mosaic virus and, occasionally, other viruses.

Sporulation of Hendersonula toruloidea in Persian walnut xylem. SOMMER, NOEL F. *Hendersonula toruloidea* Nattrass is the cause of a branch wilt disease of the Persian walnut tree, *Juglans regia* L. Frequent serious damage is observed in the central valleys of California, although the fungus is primarily associated with sunburn damage. Minor sunburn damage, unimportant in itself, predisposes the branches to infection. Although the fungus gains entrance to susceptible tissue through wounds, the wounds are not important unless sunburn is present. Microscopic examinations revealed that the fungus sporulates within the vessels of the host. Consequently, a study was made to determine if spores so produced might function to cause a secondary spread of the disease within a tree. A preliminary examination indicated that the spores did move in the xylem vessels. When the bases of branches were submerged in a spore suspension and then cut, spores moved up the branch a distance of 30 in. in 48 hours. When injections were made into intact uninjured branches, no cankers were produced. If portions of the branch were exposed to the sun after spore injection, however, cankers developed. The importance of internal sporulation in the spread of the disease in nature, however, has not been determined.

Etiology and control of soil rot of cucumber. SOWELL, G., JR. The disease of cucumber fruit known in Florida as belly rot or soil rot has been a problem of increasing importance. It is apparently a member of the so-called soil rot group of disease caused by *Rhizoctonia solani* Kühn. Inoculations with isolates of the fungus from fruit showing soil rot have resulted in typical lesions on fruit and in damping-off of cucumber seedlings. The possibility that *Pythium* sp. is associated with the disease as previously reported has not been eliminated, but techniques particularly adapted to the isolation of *Pythium* spp. have failed to reveal the presence of this fungus. A significant reduction in the amount of soil rot has been obtained by applying a pre-emergence drench containing 25 lb. pentachloronitrobenzene per acre followed by a drench containing 30 lb. of captan per acre. Several neutral copper preparations, applied as a drench containing 60 lb. per acre, followed by weekly applications of the same materials as foliage fungicides at 4 lb. per 100 gal. were equally effective. Captan applied as a drench containing 30 lb. per acre or as weekly foliage applications of 1 lb. per 100 gal. also significantly reduced the amount of soil rot. All drenches containing captan or copper were applied when the plants were 25 cm tall.

The organic acids of the wheat leaf infected with Puccinia rubigo-vera tritici. STAPLES, R. C. Leaves of Webster wheat infected with *Puccinia rubigo-vera tritici* were found to increase greatly in malic and citric acid content, with respect to controls. Maximum control of these acids is at the time when the uredospores are being shed. The estimation of the organic acids was made on removing the plants from a 10-hour dark period. Ion exchange chromatography of an 80 per cent ethanol extract of the wheat leaves also showed that neither aconitic nor succinic acids changed significantly in amount during the course of infection when compared to noninoculated controls.

Behavior of Fusarium oxysporum f. cubense in different soils and soil extracts. STOVER, R. H. In naturally infested soil, Fusarium populations were too low and too unevenly distributed for significant changes to be detected by soil plating; hence, artificially infested soils with unnaturally high populations were used. There was no evidence in natural soil *en masse* of fungus multiplication; populations declined faster in acid sandy loam favorable to disease spread than in alkaline loam unfavorable to disease spread. Addition of 25 per cent by volume of sand to soils hastened the decline. Fungus multiplication was more rapid in sandy loam than in clay loam on admission of air to infested soils after 14–21 days of anaerobiosis. Sporulation, studied in filtered aqueous soil extracts and *in situ* in soil crumbs after the addition of dextrose and nitrogen com-

pounds, was retarded or inhibited in clay loam and its extracts and promoted in sandy loam. Inhibition was reduced by treating extracts with charcoal, by Seitz filtering, or by air-drying soils before extraction and was eliminated by heat sterilization, but pH or Ca were not involved. Attempts to concentrate or characterize a sporulation inhibition or retardation factor present in soil were unsuccessful because of the interrelationships among sporulation, inhibition or retardation, and nutrition.

Toxin from germinating urediospores of the wheat stem rust fungus. SWAEBLY, MARY ANN. A heat-labile substance extracted from germinating urediospores of races 11, 15B and 56 of the wheat stem rust organism, *Puccinia graminis* Pers. var. *tritici* Erikss. & Henn., was toxic to cells of seedling leaves of wheat. Introduced into the tissues under a partial vacuum, it produced small chlorotic flecks, leaf tip necrosis, and cell-wall damage similar to the effects observed in seedlings inoculated with viable urediospores. Extracts from different races differed in their effects on seedlings, and wheat varieties differed in reaction to these extracts. Urediospores of race 15B produced a more potent toxic substance than spores of races 11 and 56; and Kentana wheat, a Kenya derivative, was more severely affected than Little Club. The toxic activity was influenced by temperature: small chlorotic flecks occurred at 65°F whereas extensive chlorosis and necrosis developed at 90°F. Seedling leaves treated with the toxin were more severely damaged by subsequent inoculation with viable urediospores than were nontreated leaves.

Fungi associated with sorghum seed in Kansas. SWARUP, GOPAL, EARL D. HANSING, AND CLARK T. ROGERSON. A study of 6 sorghum varieties, Westland, Midland, Martin, Atlas, Ellis and Sumac, during a period of 4 years (1951–1954) resulted in 8702 isolates from surface-sterilized seeds. The number of isolates obtained in the different classes of fungi were 607 Ascomcyetes, 27 Basidiomycetes, 8047 Deuteromycetes, and 21 unknowns. The isolates were distributed among 34 genera and 63 species of fungi. *Alternaria tenuis* was isolated most frequently, accounting for 7302 isolates. The other common genera of fungi frequently isolated were, in order of prevalence, species of *Chaetomium, Fusarium, Helminthosporium, Curvularia, Thielavia,* and *Aspergillus.* Differences were found in the abundance of fungi in relation to year; variety; division of the state; and viability, weight, and color of seed. Maximum isolations were obtained in 1954 seed. Grain sorghums as a group had more infected seed than forage sorghums. Maximum number of infected seed was obtained in the central zone of Kansas. Seeds that did not germinate were found to be infected slightly more often than those that germinated. Seeds in the higher weight group were found to be infected slightly more often than those in the lower weight group. There was a definite relationship between seed with poor color and high incidence of fungi.

A cytogenetical analysis of reactions to wheat streak mosaic virus in certain Agrotricum hybrids. SWARUP, VISHNU, ELIZABETH U. MCCRACKEN, WEBSTER H. SILL, JR., AND JOHN W. SCHMIDT. Cytogenetical studies, which included reactions to virus inoculation and some relationships of plant morphological characters, were made on certain Agrotricum hybrids to determine location of gene(s) for a local-lesion type of resistance to wheat streak mosaic. The F_1 showed local-lesion reaction only. In F_2 and F_3, 3 types of reactions were observed: S (systemic), LL (local lesion), and LL/S (local lesion followed by systemic necrosis). The segregation for virus reactions was at random, not based on any genetic ratio. In F_2, LL plants had significantly higher chromosome numbers and univalents (49.5 and 4.82, respectively) than the others; S types had the lowest (43.6; 2.72) numbers, and LL/S types had intermediate (45.6; 3.92) numbers. There were also differences in size of univalents present in plants of different virus reactions. Univalents (probably more than 1) of genomes X or Y of *Agropyron* spp. were found carrying gene(s) for LL not present in genomes of wheat. The F_2 plants of LL were more grass-like than were the other types: they were tall, with long narrow spikes and kernels unlike those of S and LL/S, which were more wheat-like. This suggested the probable location of genes for these grass-like characters on chromosomes that also carry gene(s) for resistance (LL).

Identity of the red-leaf virus of oats and the yellow-dwarf virus of cereals. TAKESHITA, R. M. A virus was recovered by means of aphids (*Macrosiphum granarium, M. maidis, Rhopalosiphum prunifoliae,* and *Toxoptera gramineum*) from red-leaf affected oat plants collected from 28 locations in Illinois, and from single locations in Minnesota, Iowa, Wisconsin, Massachusetts, Maine, and New York. Twenty-one of the 34 isolates caused typical yellow-dwarf symptoms on oats, barley, wheat, and rye. Although the remaining isolates have been tested on only 1 or 2 of the 4 cereal hosts, each isolate has produced typical yellow-dwarf symptoms. No evidence was obtained that the virus persisted in the soil surrounding red-leaf affected oat plants, or that the virus was seed-borne in oats. Mechanical transmission with sap from red-leaf affected oat plants has failed. The virus was found to persist in *R. prunifoliae* and *M. granarium* for 15 days, the maximum time tested. All of the above properties are characteristic of the yellow-dwarf virus originally described by Oswald and Houston. In addition, the incubation periods of the 2 viruses are identical. In Illionis, Iowa, and Wisconsin, barley and wheat plants showing symptoms of yellow-dwarf have been collected. Virus recovered from such plants has caused typical symptoms of yellow-dwarf in oats, barley, wheat, and rye.

Strains of the yellow-dwarf virus of cereals. TAKESHITA, R. M. In transmission studies with the yellow-dwarf virus, isolates differed in virulence. Some isolates caused only moderate stunting and mild leaf symptoms on the highly susceptible barley variety Blackhulless and on the highly susceptible oat varieties California Red and Coast Black. Experiments showed that unfavorable temperature and light relations were not responsible for the mild symptom expression. An isolate causing very severe stunting and an isolate causing slight stunting on barley, wheat, and oats were used for further study on a wider range of host varieties. A number of very susceptible, intermediate, tolerant, and highly resistant varieties were selected from a list tested by Oswald and Houston. The reaction of most of the host plants to the highly virulent isolate coincided with those given by Oswald and Houston; however, some of them were more severe and a few more mild. With the mildly virulent isolate, nearly all of the host plants manifested either tolerance or high resistance. The incubation period of the mildly virulent isolate was 3–7 days longer than that of the highly virulent isolate. These comparisons have been consistent in 3 different trials.

Nematocidal efficacy of some intermediate-numbered carbon fatty acids. TARJAN, A. C., AND P. C. CHEO. Undecylenic (10-undecenoic) acid proved to be an extremely effective nematocide when used *in vitro* against *Panagrellus redivivus* at concentrations of 1000 ppm. Similar testing of 3- to 16-carbon fatty acids shows that straight chain unsubstituted saturated acids of from 7 to 11 carbon atoms in length exhibit high nematocidal activity. Cysts of *Heterodera tabacum* containing viable eggs were immersed for 30 minutes in an aqueous emulsion of 2 per cent undecylenic acid. After drying for 7 days, treated cysts were immersed for 2 months in 0.01 per cent picric acid for larval hatching tests. Larval emergence from treated cysts was completely suppressed as compared to numerous larvae evacuating from untreated cysts. When burlap potato bags were lightly coated with cyst-infested soil and sprayed with or dipped in various fatty acid emulsions, only 2 per cent pelargonic (nonanoic) acid was completely effective in suppressing larval emergence. Burlap strips were dipped in 10 per cent pelargonic acid emulsion, dried for 7 days, and then infested with cysts. After 7 days, the cysts

were immersed in hatching medium. Complete inhibition of larval evacuation from cysts resulted during the 9-week observational period.

Control of black root rot of apple. TAYLOR, CARLTON F. Soil treatments were applied and apple trees were planted where trees had died of black root rot in 1942, 1945, 1947, and 1948. Untreated controls equaled the number of treatment replicates each season. Fumigants were injected in 33 holes in a 5-ft. square the summer previous to planting; other materials were applied in the planting hole. Carbon bisulphide was tested each year, all other materials in fewer seasons. All large infested roots were removed during soil preparation. Tree mortality due to *Xylaria mali* through the spring of 1955 has been as follows: carbon bisulphide (3.5 or 7 lb., covered or uncovered), 1 of 71 trees; formaldehyde, 4 of 33; Bordeaux mixture in the planting hole, 2 of 28; all other treatments, 6 of 29; and untreated, 10 of 56. Because of variations in the year of treatment, these data have been adjusted to loss over the total of growing seasons (2 trees each surviving 10 seasons equal 20 growing seasons). Percentage mortality due to *Xylaria mali* per growing season has been as follows: carbon bisulphide, 0.14 (713 seasons); formaldehyde, 1.23 (326 seasons); Bordeaux mixture, 0.85 (237 seasons); other materials, 2.75 (218 seasons); and untreated, 1.80 (553 seasons). Records are being continued on the surviving trees.

The effect of rust on yield and oil content of safflower. THOMAS, C. A. Two near-isogenic varieties, one rust susceptible (N8) and the other resistant (W14), were compared in isolated plots at Beltsville, Maryland. *Puccinia carthami* was introduced into some plots by spreader rows of inoculated plants, and the other plantings were grown rust free. Results from tests in 2 years showed that rusted N8 yielded 65 per cent as much as W14, whereas rust-free N8 yielded 95 per cent as much as W14. Oil content of N8 seed from rust plots averaged 3.7 per cent higher than that of seed from rust-free plots. Oil content of W14 seed from all plots was close to that of N8 grown rust free. Rust appeared to predispose plants to firing, to reduce amount of hull on seed, and to lower bushel weight.

Control of bacterial leaf spot of sesame by streptomycin seed treatment. THOMAS, C. A. Tests were made in 1954 and 1955 on the possible use of streptomycin treatment for the control of *Pseudomonas sesami* by eradication of the organism on naturally infested seed. Seeds of Palmetto sesame soaked for 30 minutes in solutions of 250, 500, 750, and 1000 ppm streptomycin were planted in isolated plots in Maryland and Virginia. Nonsoaked seed and seed soaked in water were planted in other isolated plots for controls. No bacterial leaf spot was found in any of the plots planted with seed treated with streptomycin. The disease was prevalent in all control plots. Concentrations higher than 500 ppm reduced the rate of seedling growth under certain conditions. None of the treatments reduced stand.

Decay of oaks caused by Hypoxylon atropunctatum. THOMPSON, G. E. *Hypoxylon atropunctatum* occurs primarily on oaks throughout the United States. It appears on affected trees as extensive flat stromata, which at first produce a conidial stage and later perithecia. Ascospores are discharged distances up to 60 mm. In the initial stages of decay, the sapwood becomes dark-brown and water soaked, later becoming lighter in color. Irregular black zones are usually present. Hyphae occur in all cells of the affected wood. The fungus has been isolated from diseased wood and ascospores. The latter produce colonies that show many variations. Cultures have not been obtained from conidia. The optimum temperature for growth on artificial media is approximately 30°C. Inoculations on living trees have demonstrated the pathogenicity of the fungus.

Partial purification of curly-top virus. THORNBERRY, H. H., AND D. D. HICKMAN. Partial purification of curly-top virus from ground diseased sugar beet leaf tissues has been obtained by aqueous extraction in 0.05 M sodium citrate buffer at pH 8.5, clarification of the liquid by passage through 4-ply cheesecloth and Celite filter cake at pH 8.5, and repeated differential sedimentation at pH 7.5 in an ultracentrifuge at 5000 $\times$ G for 15 minutes and at 44,000 $\times$ G or 80,000 $\times$ G for 2–4 hours. Infectivity of samples was assayed by vector (*Circulifer tenellus* (Baker)) transfer of sample liquids to young sugar beet plants, 1 leafhopper per plant. A preparation given 5 centrifugations and passage through a Mandler filter was infectious: 3 diseased plants showed symptoms out of a total of 20 plants exposed to leafhoppers. Virus-like rods approximately 20–30 $\times$ 150–200 mμ were detected by electron microscopy. Since the original infectious juice would have been diluted 1×10^{-8} in the extraction and purification, the infectious entity appears to be the virus-like rods.

The development of ascocarps of Endoconidiophora fagacearum. TIFFANY, LOIS H. The development of ascocarps of *Endoconidiophora fagacearum* Bretz was studied in fresh material as well as in fixed and stained sections. An intercalary densely staining ascogonium was already delimited in untreated 4-day-old cultures. Observations concerning further development were made with cultures that had been flooded or atomized with a conidial suspension of another strain of the fungus. Large multinucleate "ascogenous hyphae" arise from the ascogonium and push up into the pseudoparenchyma cells filling the centrum. These structures give rise to binucleate asci. Nuclear fusion occurs in the ascus, with meiosis and a mitotic division following in rapid succession. Three to 4 days after treatment, free uninucleate ascospores are present. The perithecial wall is formed by branches from hyphal cells adjoining the ascogonium. The neck develops by growth of the wall cells in the upper part of the perithecium.

Detached leaves for screening antibiotics. TSAO, PETER H., CURT LEBEN, AND G. W. KEITT. Two hundred fourteen actinomycete isolates inhibitory *in vitro* to 5 plant pathogenic fungi were obtained from soil samples that had been dried, mixed with $CaCO_3$, and incubated under moist conditions. The selection of isolate B74 for further work was based on antibiotic production in liquid soybean meal medium, *in vitro* inhibition of *Glomerella cingulata* and *Alternaria solani*, and reduction of symptoms incited by *A. solani* on detached tomato leaflets on toxicant agar. Leaflets were placed on agar containing culture filtrate, incubated, and then spray-inoculated with *A. solani*. B74 filtrates reduced symptoms only on parts of leaflets touching the agar. When tested on intact plants, B74 filtrates or the partly purified antibiotic did not appear to be systemic. The partly purified material had protectant action in early blight greenhouse tests, however, giving ED_{50} and ED_{95} values of 21 and 40 μg/ml, respectively.

Discoloration of potato tubers during soft rot. WAGGONER, PAUL E., AND A. E. DIMOND. *Erwinia atroseptica* (A) and *E. carotovora* (C) were identified by production of acid from alcohol. Ends of tuber plugs were placed in a suspension of washed bacterial cells at 16° and 30°C. Maceration was greater with C than with A, at both 30° and 16°. Discoloration was due to host enzymes, because autoclaved plugs remained white and raw plugs became discolored when inoculated. At 16°, A caused greater discoloration of plugs and fluid beneath than did C. Ability of water extracts of homogenized decayed and noninoculated tissue to oxidize reduced diphosphopyridine nucleotide (DPN) in the presence of catechol was measured. Of these extracts, that from noninoculated tissue was the most active, followed in order by extracts from A-infected tissue at 16° and C-infected at 30°, A-infected at 30°, and C-infected at 16°. Ability of such extracts to reduce DPN in the presence of naphthoquinone was measured. Decay reduced reductase activity at 16° and increased it at 30°. As tubers decayed, darkening occurred and oxidase activity decreased. At 16°, the darkening attained was correlated with the remaining oxidase/reductase activity; at 30° it was not.

Altering disease resistance with ionizing radiation and growth substances. WAGGONER, PAUL E., AND A. E. DIMOND. Resistance to Fusarium wilt of both susceptible (Bonny Best) and multiple-gene resistant (Pritchard) tomatoes was increased by root and decreased by shoot X-irradiation 4 days before inoculation. Single-gene resistance (Pan American) was not affected by X-irradiation although plants were stunted. Increase in resistance induced by X-irradiation of Bonny Best roots reached a maximum after about 2 days and disappeared in about 8 days at 27°C. Increase in resistance induced by 1 spray of 0.27 mM napthalene acetic acid on Bonny Best foliage reached a maximum in about 2 days and disappeared in about 24 days at 27°. The time-change in resistance induced by either radiation or growth substance was temperature dependent: at 18° both the time required to reach a maximum and that required for disappearance of resistance were longer than at 27°. Duration of increased resistance suggests that application of growth substance to seedlings before transplanting may be practical.

Hereditary resistance to tobacco mosaic in tomato. WALTER, JAMES M. Varieties with immunity or effective resistance to tobacco mosaic virus, *Marmor tabaci* Holmes, have been prime objectives in the breeding of disease-resistant tomatoes in Florida since 1942. Semi-primitive selections in advanced generations from the cross of *Rutgers* × *Lycopersicon hirsutum* Humb. & Bonpl. (P.I. 126445) with Indiana Baltimore demonstrated homozygosity for resistance to a combination of green and yellow strains of the virus by 1948. Slow but definite progress has been made in advancing this resistance to improved larger-fruited tomato types and combining it with resistances to other important diseases. The resistance to tobacco mosaic is nonsymptomatic tolerance . It has proved effective wherever tested, but unfortunately it is negated by superimposition of other viruses, such as *M. erodens* Holmes or *M. upsilon* Holmes. Counts on large, heavily-inoculated F_2 populations from crosses between resistant and susceptible stocks, the matings being those deemed most likely to lead to the practical objective, show that the ratio closely approximates 63 susceptible to 1 resistant. This indicates that the parents differ by 3 recessive genes and that the resistance is unlike any of the types recently described by other workers.

Combination of resistances to tobacco etch and tobacco mosaic in tomato breeding stocks. WALTER, JAMES M. Discovery that the resistance to tobacco mosaic in tomato described in the preceding abstract is negated by the etch virus, *Marmor erodens* Holmes, stimulated search for tomato breeding stocks resistant to etch. The Section of Plant Introduction, U. S. Dept. of Agriculture, supplied 341 accessions of Lycopersicon for testing. P.I. 183692 was found resistant. This accession is an attractive form of *L. esculentum* from Turkey. A mating between P.I. 183692 and CStMW 18, the latter being the most advanced stock with resistance to tobacco mosaic then available, resulted in a few selections that proved to have the resistances to etch and tobacco mosaic in combination. These lines have now been tested and refined by selection through the F_5, and they have proved to be resistant to both viruses, whether the viruses are applied separately or in combination. Younger stocks from crosses designed to advance the resistances in improved tomatoes are showing promise. Preliminary studies suggest that the resistance to etch is actually immunity and that it is controlled by a single recessive gene.

Epidemiology of wheat rusts in Australia. WATSON, I. A. Studies on variability in *Puccinia graminis* var. *tritici* in Australia have shown the presence of rust fungi whose origin is presumed to be closely connected with the varieties used in breeding. Since 1930, the genes Ka_1, Kc_1, and Kb_1 from Kenya wheats and from *Triticum durum* have been used in that order as sources of resistance against the prevalent race 126 in Australia. As a result, 3 new biotypes of the rust fungus closely resembling race 126, but clearly differentiated on varieties having Ka_1 or Kc_1, were identified. Except for slight variations on Acme, their reactions agree with those of race 126, and they also have the sensitivity to temperature shown by race 126 on the other durums. As it is unlikely that barberries played any part in their origin, they are regarded as stepwise mutations from the original 126. The gene Kb_1 present in Dowerin and Festival is still effective against all stem rusts in Australia. Similar stepwise changes in pathogenicity have been found in *Puccinia triticina.* Only 2 races, 26 and 95, were isolated prior to 1930. As a result of the use of Webster, Gaza, Spica, Uruguay, and Hope in breeding programs, at least 16 races and biotypes of the rust organism can be readily identified from nurseries maintained throughout the year.

Studies on blind pocket psorosis of lemons. WEATHERS, L. G., E. C. CALAVAN, AND J. M. WALLACE. In a disease study of lemon groves in southern California, a considerable number of Eureka lemon trees in one orchard were found to be showing symptoms characteristic of those caused by the blind pocket strain of psorosis virus. Graft inoculations were made from infected trees to various citrus seedlings. Rangpur lime, West Indian lime, grapefruit, Dorshapo sweet lemon, Rough lemon, and Cuban shaddock seedlings inoculated with the virus and then topped showed severe shock injury of the newly developed leaves and shoots 2–4 weeks after the plants were inoculated. The growing tips of the young shoots withered and died. The older leaves developed necrotic spots and dropped. At later stages, the young shoots died back. Some of the seedlings were killed by the virus. Other seedlings recovered from the initial shock but failed to grow normally and later developed leaf symptoms typical of psorosis. Inoculations to sour orange and sweet orange seedlings produced only leaf symptoms of psorosis. Cross inoculation tests indicated that blind pocket of lemon is related to psorosis A.

A gladiolus disease caused by Curvularia sp. WEBER, G. F., AND L. VAN WEERDT. Gladiolus parasitized by *Curvularia sp.* has been observed in Florida for almost a decade. The fungus in the field causes a characteristic tan to brown leafspot, often zonate, and premature death frequently results from stem and petiole girdling on young nonblooming plants. A smudgy flower blight occurs under favorable weather conditions. Irregularly shaped brown to black lesions often are found on the corms of blooming stock and continue to develop in storage and serve as a means of survival of the fungus from season to season. The fungus was readily isolated, and it grew and sporulated well on potato-dextrose agar at a wide range of temperatures, reactions, and light intensities. The disease was reproduced on the various parts of the host by inoculation experiments. The genus *Curvularia,* as established by Boedijn using as his type *Acrothecium lunatum* Wakk., includes a group of fungi producing 3–4 unequal-celled, colored, and angular or curved conidia singly or in whorls on aerial conidiophores. Comparison of the Florida fungus with cultures of the type fungus from Boedijn's laboratory in Java and from Baarn and with isolates from certain sources in the United States shows wide differences in morphology and physiology. Neither of the transfers from type fungi were pathogenic on the very susceptible Picardy variety of gladiolus commercially grown in Florida.

Pathological histology of tomato internal browning. WHARTON, DAVID C. Histological studies show that internal browning is usually confined to the outer fleshy pericarp of the fruit but in severe cases may extend into the septa and central column. The tissue discoloration radiates from the stem-end and is restricted to the fleshy parenchymatous tissue. It is often accompanied by a collapse of the large thin-walled parenchyma cells, particularly midway between vascular bundles. It is this cellular collapse that is responsible for the furrowed appearance of the fruit surface. The content of many affected cells is granular in nature,

indicating a disintegration of the cytoplasm. Neither the vascular tissue nor the small parenchyma cells adjacent to it appear to be directly affected by the disease.

The structure of the wheat stem in relation to stem rust resistance. WILCOXSON, ROY D. Sclerenchyma and collenchyma tissue and the epidermis over the collenchyma tissue in stems of 34 wheat varieties were compared for their ability to tolerate or resist attack by *Puccinia graminis* var. *tritici*. Stems of resistant varieties had small amounts of collenchyma tissue broken into many single bands, but susceptible varieties had large quantities in compound bands. Varieties did not differ in thickness of collenchyma cell walls. Amounts of intercellular space in collenchyma tissue varied with variety when numbers of substomatal cavities per stem area were compared; in general, the most susceptible varieties had the most space. Thickness of epidermis did not vary with variety among those measured. Structural differences in sclerenchyma tissue were most striking between durum and bread wheats. In susceptible varieties, breaking of sclerenchyma during rust development was correlated with the presence of many intercellular spaces and short fiber cells, whereas in resistant varieties no breaking occurred and intercellular spaces were absent and fibers were long. Tolerant varieties of durum and bread wheats had smaller amounts of compact collenchyma tissue, and the sclerenchyma tissue was resistant to breakage. Apparently, several morphological characters contribute to rust resistance.

Development of the perithecium of Endoconidiophora fagacearum. WILSON, CHARLES L. A cytological study was made of the developing perithecium of *Endoconidiophora fagacearum* Bretz. The fungus was grown on agar and spermatized with conidia. Material was collected at intervals of 4 to 60 hours. Ascogonia consisted generally of 3 bulbous vacuolated cells and a specialized receptive hypha extending upward among the conidiophores. Fertilization is followed by rapid nuclear multiplication and formation and multiplication of seemingly unwalled ascogenous cells containing 2 nuclei that soon fuse. At the same time, the neck of the perithecium elongates. Mature asci are generally found first in the center of the perithecium. Perithecial development differs little from that of other closely related species except in the presence of a receptive hypha.

New materials as eradicant fungicides. WILSON, E. E., AND J. M. OGAWA. When applied as sprays to dormant almond trees, proprietary formulations of dinitro-*o*-*sec*-amylphenol (DNAP) and of a 1:4 mixture of DNAP and 2-*sec*-butyl-4,6-dinitrophenol (DNBP) compared favorably with sodium pentachlorophenate (SPP) in eliminating the conidial inoculum of *Sclerotinia laxa* from hold-over sources. Reduction in the amount of blossom infection following use of these materials ranged from 73 to 82 per cent. The triethanolamine derivative of DNBP, however, was less effective than either of these compounds. The percentage reduction in fruit infection by *Coryneum beijerinckii* was 71 for SPP, 59 for DNAP, and 94 for a proprietary formulation of *N-phenylmercuriethylenediamine* (PMED). The percentage reduction in fruit infection by the almond scab fungus (presumably *Cladiosporium carpophilum*) was 34 for SPP, 20 for DNAP, and 60 for PMED. In another test, SPP reduced fruit scab by 35 per cent.

Comparative control of radish yellows by various soil fumigants and fungicides. WILSON, J. D. Radish yellows (caused by *Fusarium oxysporum* f. *conglutinans* (Wr.) Snyd. & Hans.) has become a serious disease in several locations in Ohio during the past 5 years. Various attempts have been made to control it in the field, none of which have been very successful. Control has been much better in greenhouse benches where the materials being tested could be more thoroughly mixed with, or incorporated in, the soil. The compounds tested have included a variety of fungicides (soil and foliage), as well as most of the so-called fumigants that have been developed for the control of nematodes. Of the fungicides tested, Crag 974 (95 per cent tetrahydro-3,5-dimethyl-2*H*-1,3,5-thiadiazine-2-thione) gave the best results. Vapam (sodium methyldithiocarbamate) and formaldehyde also were comparatively effective. Of the materials that might be more definitely classed as fumigants, chloropicrin and EDB (ethylene dibromide) gave good results when used at a rate comparable to that that would be required for nematode control in muck soil. EDB and D-D (1,3-dichloropropene; 1,2-dichloropropane) were slightly less effective.

Control of root-knot on carrot, celery, and onion in muck soil by EDB and D-D. WILSON, J. D. Since spring applications of these fumigants failed in 1954 to give a worthwhile degree of control of root-knot, caused by *Meloidogyne hapla* Chitwood, on carrots grown in muck soil, fall application was tried. EDB (ethylene dibromide) (W-85) was applied at 12 and 9 gal. per acre and D-D (1,3-dichloropropene; 1,2-dichloropropane) at 45 and 30 gal. per acre to replicated plots in the fall of 1954. In the spring of 1955, the differently treated areas were planted to carrots, celery, and onions. Onions showed the least yield response (plots treated with EDB, 12 gal./acre, yielded less than the untreated check because of injury) of the 3 crops and carrots the greatest, with celery only slightly less than carrots. The respective percentages of carrot root infestation were 65.7, 24.4, 21.3, 8.2, and 5.5, respectively, for no treatment, D-D at 30 and 45 gal. per acre, and EDB at 9 and 12 gal.

Helminthosporium victoriae, a pathogen of bean. WINSTEAD, N. N., AND T. T. HEBERT. In May, 1954, a disease with unusual symptoms was present on marketable sized green pods of Tendergreen variety of bean in a field in southeastern North Carolina. Lesions on the pods were small water-soaked spots, approximately 1 mm in diameter, with black necrotic centers. On the stems, petioles, and veins of leaves, the lesions appeared as small narrow dark brown to black streaks. The disease was found also in the field on the bean varieties Black Valentine, Bountiful, Contender, Tenderlong 15, and Wade. Isolations consistently yielded a species of *Helminthosporium*. Symptoms similar to those observed in the field were reproduced on bean plants in inoculation tests in the greenhouse. The disease has been observed in the field only where beans were grown adjacent to fields of oats heavily infected with *H. victoriae* Meehan & Murphy. Cultures of *H. victoriae* and the Helminthosporium fungus from bean were similar in size of spores, cultural characteristics, and pathogenicity on beans and oats. It was concluded that the Helminthosporium isolated from bean was *H. victoriae*.

Eradicant treatments for narcissus bulbs and gladiolus corms harboring soybean nematode cysts. WINSTEAD, N. N., AND C. B. SKOTLAND. The soybean cyst nematode, *Heterodera glycines* Ich., has been found only in a small area in southeastern North Carolina where soybeans are often grown in rotation with gladiolus and narcissus. Because of the possibility that cysts of the nematode might be disseminated as contaminants on gladiolus corms and narcissus bulbs harvested from infested soil, tests were made to determine nonphytotoxic treatments that would kill unhatched larvae in cysts. Bulbs, corms, and cysts were collected and steeped in materials recommended for the control of bulb and corm storage rots and the bulb and stem nematode. After steeping, 50–100 cysts were placed in 4-in. clay pots, and seeds of Roanoke soybean were planted. After 2 months, soybean roots and soil from each pot were examined for the presence of new cysts, larvae, and males. Of the several treatments tested, 0.5 per cent formalin (45°C for 3 or 4 hours) and hot water (48°C for 30 minutes) killed unhatched larvae. The use of Dowcide B (85 per cent sodium 2,4,5-trichlorophenoxide) 3-100 in a 30-minute prestorage steep at harvest killed the unhatched larvae in cysts and also gave effective control of the Fusarium bulb and corm rots of narcissus and gladiolus.

Temperature as a possible factor in the control of fire-

blight with streptomycin. WINTER, H. F., AND H. C. YOUNG. The results of apple fireblight experiments at Wooster in 1955, involving the use of streptomycin sprays on inoculated trees, are at variance with results of similar experiments reported by the authors in 1953 and 1954. Significant reduction of blossom blight was again obtained in 1955, but the degree of control was low as compared to that obtained the 2 previous seasons. In searching for a possible explanation of the poor control obtained in 1955, it was noted that temperatures during the apple blossoming season that year were lower than in the other 2 years. The mean temperature for the first 6 days from early bloom through full bloom in 1955 was 54°F compared with 62° and 63° for like periods of 1953 and 1954, respectively. The averages of daily maximum temperatures for the same periods were 63°F in 1955 compared with 75° and 73° in 1953 and 1954, respectively. The low temperatures prevailing during the critical blossoming period of 1955 at Wooster are offered as a possible explanation of the low degree of fireblight control obtained with streptomycin in the 1955 experiment.

Serology of potato yellow-dwarf virus. WOLCYRZ, SYLVIA, AND L. M. BLACK. Several strains of potato yellow-dwarf virus were grown in *Nicotiana rustica* and purified by ultracentrifugation and electrophoresis in density-gradient columns of sucrose. Purified virus with adjuvant was injected intramuscularly into rabbits to obtain antisera. Virus prepared by density-gradient centrifugation but without electrophoresis was tested against antisera in precipitin ring-reactions where it gave an end-point titer of 1:32, if it is assumed that its concentration in plant tissue is 1:1. Homologous antisera had dilution end-point titers as great as 1:1280. Heterologous reactions gave lower titers, indicating minor antigenic differences in virus strains. Three injections a week apart can give serum titers of 1:640; a booster shot 13 weeks after the third injection may double the titer. Heating purified virus for 5 minutes at 80°C prior to injection did not affect its ability to produce antibodies. Particles with a lower sedimentation rate than the virus but antigenically related to it were detected in juice of diseased plants. Purified virus stored frozen at —10°C in solutions containing protective ions and high concentrations of sucrose retained 50 per cent of its antigenicity for at least 33 weeks.

Further aids in virus inoculations. YARWOOD, C. E. When tobacco mosaic virus inoculum was suspended in water, about 7 times more lesions resulted from standard inoculations on bean at 11 a.m. to 5 p.m. than from inoculations at 6 a.m. to 8 a.m. The effect of time of day of inoculation was less for inoculations on *Nicotiana glutinosa*, less when the inoculum was suspended in 1 per cent K_2HPO_4, and less when the leaves were dried quickly after inoculation. The increase (in number of lesions) due to 1 per cent Na_2SO_3 in the inoculum was almost as great as that due to K_2HPO_4 and could not be explained on the basis of increased longevity of the virus. With canna mosaic virus, which appears to be a strain of yellow bean mosaic virus, more lesions resulted on primary bean leaves when the growing points of the bean plants were removed at the time of inoculation than when they were not removed. With a virus from peach trees with yellow bud mosaic, more lesions resulted when true leaves of sunflower were inoculated on their lower surfaces than when inoculated on their upper surfaces. With all other virus-host combinations tested, infection was greater from inoculations on upper leaf surfaces.

Phaseolus coccineus as a source of root-rot resistance for the common bean. YERKES, WILLIAM D., JR., AND GEORGE F. FREYTAG. Crosses between races of the common bean (*Phaseolus vulgaris* L.) and the Coccineus complex (*P. coccineus* L., *P. multiflorus* Willd.) to transfer disease resistance factors usually fail, because of genetic aberrations and self-sterility in the progeny. A cross between a Canario type bean (*P. vulgaris*) and a wild Ayocote (*P. coccineus*) has proved to be self-fertile in the F_1 with no malformed parts. The wild parent root type, highly resistant to root rot, was present in the F_1. Back crossing to *P. vulgaris* with selection for the wild type root promises to lead to the production of self-fertile root-rot resistant lines. Hybrids between *P. vulgaris* and *P. coccineus* may make possible the transference of other disease resistance factors.

Races of Colletotrichum lindemuthianum in Mexico. YERKES, WILLIAM D., JR., AND MOISÉS TÉLIZ ORTIZ. Identification of collections made in Mexico of *Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav. has resulted in the discovery of at least 4 new groups of races, each of which is composed of several biotypes. These races greatly complicate the breeding of new bean varieties. Certain correlations between bean races and susceptibility to specific racial groups of the fungus have been observed. The canario group is most susceptible to group 6, the bayos to groups 4 and 5. The black beans are variable in susceptibility.

Control of late blight on tomato with streptomycin. ZAUMEYER, W. J., AND S. P. DOOLITTLE. Tomato seedlings about 8 in. high were effectively protected against infection by *Phytophthora infestans* with 3 commercial antibiotics (Agri-mycin 100, which contains streptomycin and oxytetracycline; Agristrep, which contains streptomycin sulfate; and Phytomycin, which contains streptomycin nitrate) under greenhouse conditions. Plants sprayed with any of these preparations at a concentration of 100 ppm of streptomycin, inoculated with a spore suspension of the late blight fungus 24 hours later, and incubated in a fog chamber for 48 hours showed very slight infection. In contrast, the untreated check plants were severely infected. The disease index rating of the treated plants was 0.4, whereas that of the untreated checks was 4. Plants completely protected from infection were given a zero rating whereas those severely infected were given a rating of 4. A spray containing 100 ppm of pure streptomycin was less effective in reducing infection than the commercial formulation sprays of the same streptomycin concentration. In limited tests, sprays containing 100 ppm of crude streptomycin plus 1 per cent glycerol were less effective than those containing streptomycin alone at the same concentration.

Control of downy mildew of lima beans with streptomycin. ZAUMEYER, W. J., AND R. E. WESTER. Excellent control of downy mildew (caused by *Phytophthora phaseoli*) of lima beans (variety Thorogreen) was obtained with commercial streptomycin formulations (Agri-mycin 100, which also contains oxytetracycline; Agristrep; and Phytomycin) under greenhouse conditions. Lima bean plants sprayed with any of these at a concentration of 100 ppm of streptomycin and later inoculated with a spore suspension of the mildew fungus were almost completely protected against infection. Pure streptomycin sulfate sprays were less effective in controlling the disease than the crude streptomycin formulation sprays. The latter, used at 50 ppm of streptomycin, gave better control than pure streptomycin at 100 ppm. Sprays containing 50 and 100 ppm of streptomycin plus 1 per cent glycerol were no better than those containing streptomycin alone or streptomycin in combination with oxytetracycline. An Agri-mycin spray containing 25 ppm of streptomycin and the same amount of neutral copper gave considerably better protection against downy mildew than did copper alone at 50 ppm and slightly better than Agri-mycin alone at 50 ppm of streptomycin. Agri-mycin sprays at 25 ppm of streptomycin gave no protection against the fungus. A streptomycin dust containing 1000 ppm of streptomycin afforded the same protection as sprays at 100 ppm. Streptomycin was not effective when applied 48 hours after inoculation.

Differential action of medium and fungus in toxicity of copper-8-quinolinolate. ZENTMYER, GEORGE A., AND JAMES G. HORSFALL. The action of a fungicide on different fungi and on different media often furnishes a clue to mechanism

of action. The growth of mycelial transfers of *Aspergillus niger* and *Botryosphaeria ribis* (imperfect stage: *Dothiorella gregaria*) was compared on Czapek's agar at pH 6.5, with and without 2 per cent Casamino acids. *B. ribis* seems unique among known fungi in showing resistance to copper-8-quinolinolate on the basal medium. It is much more resistant than *A. niger*. On the other hand, *B. ribis* is less resistant than *A. niger* to 8-quinolinol or copper sulfate. On the basal medium plus Casamino acids, copper-8-quinolinolate acts like its components, and *B. ribis* is appreciably less resistant than *A. niger*. Spectrophotometric tests show that 2 per cent Casamino acids will remove copper from copper-8-quinolinolate and liberate oxine. It is suggested that 1) on Czapek's agar, copper-8-quinolinolate permeates poorly into *B. ribis* or does not ionize inside and liberate the 2 moieties; and 2) on Czapek's agar plus Casamino acids, copper-8-quinolinolate gives up its copper to the amino acid complexes, forming complexes that are more toxic to *B. ribis* than to *A. niger* presumably because they permeate more freely and/or are degraded more readily than copper-8-quinolinolate by *B. ribis* to liberate copper ion. Thus, both 8-quinolinol and ionic copper are available to poison the fungus.

Reversal of fungitoxicity of 8-quinolinol and copper-8-quinolinolate by other chelators. ZENTMYER, GEORGE, AND SAUL RICH. The fungitoxicity of 8-quinolinol to spores and mycelium of *Aspergillus niger* and mycelium of *Botryosphaeria ribis* was reversed on Czapek's agar by casein hydrolysate, L-histidine, and L-cysteine. L-Cysteine was the most effective of these materials. L-Methionine, L-glycine, and L-cystine had little or no effect. Quinaldic acid and dithizone reversed the toxicity of 8-quinolinol to the spores of *Stemphyllium sarcinaeforme*. The toxicity of copper-8-quinolinolate to spores and mycelium of *A. niger* and mycelium of *B. ribis* also was reversed by L-cysteine. Spectrophotometric studies showed that L-histidine and L-cysteine at the reversing concentrations (0.5 per cent) remove copper from copper-8-quinolinolate, producing the copper amino acid chelate plus free 8-quinolinol. These chelators apparently reverse the fungitoxicity of 8-quinolinol and the copper complex by keeping the copper in the system away from 8-quinolinol or by taking copper away from the already formed copper 8-quinolinolate.

A CENANGIUM ASSOCIATED WITH SOOTY-BARK CANKER OF ASPEN [1]

Ross W. Davidson and Edith K. Cash [2]

SUMMARY

Sooty-bark canker of aspen, described here for the first time, is reported from the central Rocky Mountains. It is common mainly in mature and over-mature stands and occurs at various heights on the trunk. The bark becomes blackened and remains intact over the cankered area. In 3 to 5 years, a discomycete fungus, *Cenangium singulare* (Rehm) comb. n. fruits abundantly on the cankered bark. The fungus may occur in the centers of cankers before they girdle the affected trees, but it is most abundant on diseased bark of killed trees.

Aspen (*Populus tremuloides* Michx.) is subject to a number of canker diseases. Meinecke (3), in his study of diseases of aspen in Utah, mentioned a common trunk canker that is characterized by concentric areas of exposed wood surrounded at the canker margins by flaring, outrolled, dead bark. In Colorado, this canker occurs on occasional trees scattered through young or old stands. It is also abundant in localized areas where almost every tree is infected. Often an affected tree may have a large, old canker near the base of the trunk and other progressively smaller cankers higher up. The writers have never observed a fungus associated with this type of canker, which Boyce (1) has referred to as "black canker of aspen."

Another large previously undescribed canker on aspen is common in most areas of the central Rocky Mountains. It is especially abundant in stands on the western slope of the Continental Divide in Colorado. It has been tentatively named sooty-black canker of aspen, and this paper presents a preliminary report of the canker and describes a fungus that seems to be consistently associated with it.

Sooty-bark canker is rather uniformly distributed through older or mature stands. It becomes especially abundant in timber that is dying from old age or other causes. The canker has seldom been found in young stands (up to 60 years), but is occasionally present in 60- to 80-year-old stands and sometimes abundant in stands 80–150 years old.

Sooty-bark canker develops rather rapidly and may girdle a tree in a few years. Cankers develop at any point on the trunk up to a height of 60–70 feet. Sometimes they start at old wounds, such as basal fire scars or sun scald injuries, but they may also start at points where there are no apparent injuries. Cankers may reach a length of 10–15 ft. on large stems before they girdle the tree. The bark over the cankered area usually remains intact and tightly attached to the wood, even after the tree dies (Fig. 1,A). The cankers are not conspicuous but may have a slightly target-like appearance where part of the outer white surface has flaked away in a somewhat zoned pattern exposing part of the blackened inner bark. Except for the thin white outer layer, the bark becomes a uniform sooty black. When the white outer surface is removed, the canker margin is very distinct (Fig. 1,B).

Young cankers do not fruit conspicuously, but frequently numerous fruiting primordia (pycnidia?) cause roughened areas near the margins. None of these have been collected in good sporulating condition. Small insects are often present and may feed on these fruiting bodies. *Cytospora chrysosperma* Fr. is sometimes found as a secondary fungus associated with these cankers, but it does not cause them.

The blackened bark usually remains tightly attached to the wood for several years after the trees die and fall to the ground. The fungus seems to cement the bark to the trunk and produces a peculiar pattern on the wood that is exposed after the bark finally weathers off (Fig. 1,D).

FRUITING OF CENANGIUM ON OLD BARK.—Apothecia usually develop abundantly on the old diseased black bark or underneath the loosened white surface layer (Fig. 1,C). They are light gray on the exterior and curled up in angular to hysteroid shapes, which upon moistening open to reveal themselves as discoid or urn-shaped (Fig. 2).

The discomycete is present at all seasons and probably disseminates ascospores at any time of the year when moisture and temperature are favorable. The spores are forcibly ejected, indicating that they are disseminated by wind.

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FIG. 1. Sooty-bark canker of aspen. A) Canker at base of mature tree; B) Same canker with part of bark removed from margin; C) Cenangium fruiting bodies on old bark; D) Wood from which old diseased bark has weathered off.

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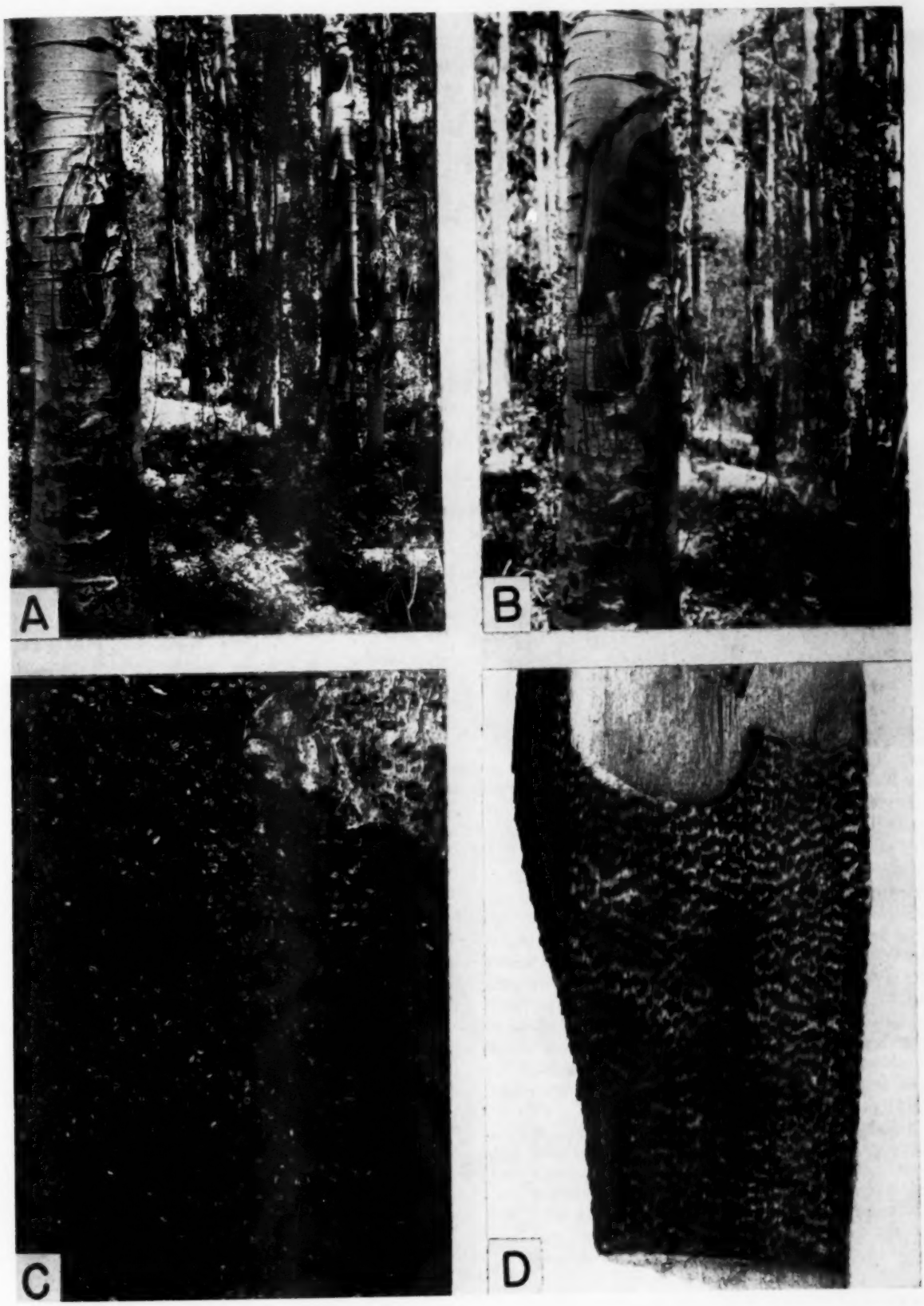
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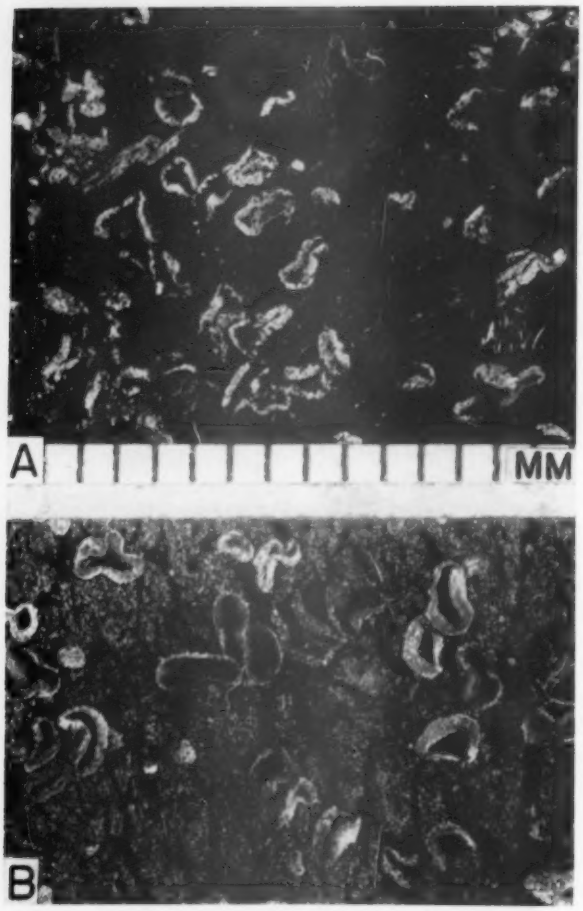

FIG. 2. *Cenangium singulare* (Rehm). A) Closed apothecia; B) Apothecia opened or partly opened from exposure to moisture (magnified several times).

CLASSIFICATION OF THE ASPEN CANKER FUNGUS.—The discomycete described by Ellis and Everhart (2, p. 100) in 1888 as *Dermatea pruinosa* Ell. & Ev., collected on decaying bark in Colorado by Cockerell, appears to be the same as the fungus found fruiting so abundantly on the old sooty-bark cankers. Seaver placed it in *Cenangium* in 1951, making the combination *C. pruinosum* (Ell. & Ev.) Seaver (5, p. 300). Seaver quotes from a note by Ellsworth Bethel on an 1898 herbarium label that "this is abundant everywhere in the mountains where aspen is found." Its association with old cankered bark has not been mentioned previously.

Apparently the species had been considered a variety of *Cenangium populneum* by Rehm and published as *C. populneum* (Pers.) Rehm var. *singulare* Rehm by Starbäck in 1895 (6, p. 19, Fig. 7). The description was copied by Saccardo and Sydow in 1899 (4, p. 796). The Ellis and Everhart name as given by Seaver (*C. pruinosum*) is preempted for a different fungus, *C. pruinosum* Ces. 1854. It is necessary, therefore, to rename it and the varietal name used by Rehm is proposed and raised to species rank as follows: *Cenangium singulare* (Rehm) comb. n.

HERBARIUM SPECIMENS EXAMINED.—The 6 herbarium specimens that follow were examined and seemed to be the same as those collected recently from old cankered aspen bark. The first 3 are from the New York Botanical Garden; loaned through the courtesy of Dr. D. P. Rogers. The other 3 specimens are in the National Fungus Collections, Plant Industry Station, Beltsville, Maryland, and give information on distribution.

Type specimen, *Dermatea pruinosa* Ell. & Ev., Colorado, 1888, coll. T. D. A. Cockerell.

Bethel No. *258-a*, on aspen, Buena Vista, Colorado, August, 1898.

Another specimen as *Cenangium populneum* (changed from original *C. furfuraceum*), Colorado, no other data.

Cenangium populneum Rehm var. *solare* (error for *singulare* Rehm). Reliquiae Farlowianae *104* on bark of *Populus grandidentata*, New Hampshire, May 18, 1908, W. G. Farlow.

Cenangium populneum (Pers.) Rehm var. *singulare* Rehm on *Populus trichocarpa*, Priest River, Idaho. October 1920, coll. J. R. Weir, det. E. K. Cash, Forest Path. *71044*; on *Populus* sp., Neebish, Mich. Oct. 1919, Herb. E. T. & S. A. Harper *1531*, det. E. K. Cash.

Cenangium pruinosum (Ell. & Ev.) Seaver, on *Populus* sp., S. Aurora Ontario, Oct. 2, 1932, coll. H. S. Jackson, det. F. J. Seaver.

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NATIONAL FUNGUS COLLECTIONS
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EFFECT OF SEED TREATMENT ON SEEDLING STANDS AND ON HAY YIELDS OF FORAGE LEGUMES AND GRASSES [1]

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SUMMARY

Seedling stands and hay yields of alfalfa, red clover, birdsfoot trefoil, orchard grass, smooth bromegrass, Sudan grass, and timothy grown from seed treated with protective fungicides were compared with stands and yields produced by untreated seed. Field plots were located at Ithaca, New York, and in some outlying New York counties. Experiments were performed in each of 4 years, 1950 through 1953. Seeds were usually sown broadcast with or without nurse crops on soils that varied in type, fertility, drainage, and cropping histories. Plantings usually were made during May, but a few were made in early June; stand counts were made 5–7 weeks after the forages were sown. Hay yields of the perennial species were measured in their second growing season.

Treatment of the forage seeds with Arasan or with Phygon Seed Protectant did not increase seedling stands and hay yields above stands and yields of untreated seed. Likewise, Orthocide 75, which was used only in 1953 on alfalfa, Ladino clover, red clover, smooth bromegrass, and timothy, did not increase seedling stands above those from untreated seed. There was no evidence that these fungicides depressed stands and yields of the forages on which they were used.

Treatment of seeds of many cereal and vegetable crops with fungicidal chemicals for control of seed-rot and damping-off is a widely established practice. However, seed treatment has not been widely adopted for the commonly grown small-seeded forage legumes and grasses because it has never been conclusively demonstrated that field stands and hay yields are improved by this practice.

Since 1935 some information has accumulated concerning the responses of small-seeded forage legumes to seed-treatment chemicals. This information is based mostly on experiments performed in greenhouses (5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18) and/or in spaced rows planted in the field (5, 8, 11, 14, 16, 17, 18). Kreitlow et al (16) adequately reviewed the literature through 1950. The trend of the results obtained in greenhouse and field row tests noted above seemed to indicate some beneficial results from treatment of forage legume seed with fungicides. For the most part, this is true only of the results obtained in greenhouse tests. Since the usual manipulation of the greenhouse environment tends to favor the activities of some seed-rotting and damping-off fungi, this trend of results should not be unexpected. It is important to note, however, that neither the greenhouse nor the field row test results consistently favored the practice of treating forage seeds with fungicides. Results of research on forage seed treatment published since 1950 are reviewed below. In general, these results are similar to those reported earlier.

Gerdemann (11) studied the effects of Arasan, Ceresan M, and Phygon XL-DDT on seeds of red clover, alfalfa, and white-flowered biennial sweetclover planted in wet and dry soil in the greenhouse and in randomized, replicated 8-ft. rows in the field. In the greenhouse tests, sweetclover benefited from treatment with some but not all of the fungicides. In contrast, plantings of alfalfa and red clover from untreated seed were significantly better than those from treated seed. In the field row tests, there were no benefits from treatments of the seed and some treatments injured germinating seed. Injury due to seed-treatment chemicals was more severe at low than at high soil moisture. Gerdemann (12) also studied the effect of Arasan on red clover seed planted in the greenhouse in warm (70–75°F) and cold (45–55°F) soils infested with a Pythium isolate. Moisture was kept high in all tests. Damping-off was much more severe in the warm than in the cold soil. Treatment of the seed with Arasan gave a low degree of control in the warm soil but did not increase seedling emergence in the cold soil above that of the check. Unpublished results obtained at the Cornell Agricultural Experiment Station have shown, likewise, that seed rot and damping-off of alfalfa are likely to be more severe in warm soil than in cold soil. Treatment of alfalfa seed with Arasan or with Phygon, however, gave little or no control in warm soil and poor to fair control of damping-off in cold soil.

Kernkamp (14, 15) performed seed treatment tests with alfalfa, red clover, and sweetclover. In greenhouse tests, treatment generally increased seedling stands over those from untreated seed. In the field row tests, only alfalfa was consistently benefited from seed treatment. It was emphasized that if alfalfa seed had been mechanically injured or if it was of lowered quality for any reason it would respond to treatment.

Scanty information is available concerning treatment of grass seed with fungicides. In 2 series of tests in

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the greenhouse on different types of soil, Fulkerson (10) recorded the effects of 7 fungicides on the seed of each of 8 grass species and on 5 species of small-seeded legumes. In the first series, seed treatment improved seedling stands of most of the grasses and legumes, but some species did not respond to treatment in a second series.

Fischer and Meiners (9), who were primarily concerned with control of head and stripe smuts in certain grasses, reported results indicating that seed-treatment chemicals that controlled head smut also increased seedling stands.

None of the above experiments on forage seed treatment were performed under conditions that closely approximated those on the farm. Kreitlow et al (16) exposed treated and untreated alsike clover, red clover, and Sudan grass seed to more or less typical farm culture. The responses of these forages to seed treatment were variable and, in general, only Sudan grass seemed to be benefited by treatment under these conditions. In contrast with some of the above results are those anonymously reported by the Semesan section of the E. I. duPont de Nemours & Co., Inc. (1, 2, 3) and others (4). These reports were concerned with the effects of Arasan on seedling stands of several forage legumes and grasses in commercial fields in many parts of the United States. Wide variation in seedling stands both from treated and from untreated seed was encountered. In general, the results decidedly favored the practice of treating the seed of various forage species with Arasan.

The published results concerning treatment of small-seeded forage legumes and grasses with fungicides may be summarized as follows: 1) tests performed in the greenhouse often, but not always, resulted in benefits from seed treatment; 2) benefits from treatment varied widely depending on forage species, seed-treatment chemicals, soil moisture, soil temperature, and types of damping-off fungi; 3) adequate tests have not been performed in the field; and 4) there are no published records of attempts to correlate yields of hay with seed treatment.

The object of the investigation reported herein was to determine the effects of some seed-treatment chemicals on seedling stands and hay yields of important small-seeded forage legumes and grasses in field plots extensive enough to provide the normal hazards of forage culture on the farm. The results presented were accumulated from experiments performed in each of 4 years, 1950–1953.

MATERIALS AND PROCEDURES.—Forage species used in the seed treatment experiments were alfalfa, birdsfoot trefoil, Ladino clover, red clover, smooth bromegrass, orchardgrass, timothy, and Sudan grass.

Viability of the different kinds of seed was determined by planting them in flats of disinfested clay loam soil to which 20 per cent sand was added. Percentage of viable seed was based on the number of seeds planted and the number of seedlings that emerged.

The percentage germination of seed of each of the forage species and varieties for the years 1950 to 1953 inclusive was as follows: alfalfa—80–98 for Ranger, 72 for Narragansett, 96 for Grimm; birdsfoot trefoil—53–56 for Empire, 65 for Viking; Ladino clover—53 for California certified; medium red clover—78–80 for Kenland, 83 for common; bromegrass—48–65 for Lincoln, 83 for Canadian common; orchardgrass—64–87 for common; Sudan grass—94 for California # 23, 81–92 for Piper; timothy—87 for Milton, 73–99 for common.

Treatment of seed.—Arasan (50 per cent bis(dimethylthiocarbamoyl) disulfide) and Phygon Seed Protectant (50 per cent 2,3-dichloro-1,4-naphthoquinone) were used respectively at dosages of 8 and 6 oz./100 lb. of seed. Orthocide 75 Seed Protectant (75 per cent *N*-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide) was used at 6 oz./100 lb. in some of the 1953 tests. The dry fungicides were mixed with the seed either in glass or metal containers. An additional quantity of fungicide equal to 1 per cent of the weighed dose was added to correct for material that adhered to the container. The different fungicides adhered very well to the different kinds of seed. Treated and untreated batches of seed were kept in dry storage until they were planted.

Planting seed.—A randomized split-plot design with 6 replications was used for all experiments on the experiment station farms in the vicinity of Ithaca, New York, in 1950, 1951, and 1952. Strip-plot plantings without replication were established on 2 experiment station farms, 1 in each of the years 1952 and 1953. Also, in 1953, strip-plot plantings were established on 1 privately owned farm in each of 4 widely separated New York counties.

The replicated split-plot tests were established on each of 2 experiment station farms in 1950 and 1951 and on 1 station farm in 1952. In the field design, the main plot consisted of a single forage species and the sub-plots consisted of the differently treated lots of seed of that species, including a control. The main plots were 15 ft. $\times$ 20 ft. and the sub-plots were 5 ft. $\times$ 20 ft.

The rates of seeding in lb. per acre for the randomized split-plot experiments were as follows for the different forages: alfalfa, 6; red clover, 5; birdsfoot trefoil, 5; smooth bromegrass, 8; orchardgrass, 4; timothy, 4; and Sudan grass, 25.

Immediately before sowing the seed, the quantity needed for each sub-plot was mixed with about 1.5 quarts of moist soil, and the inocula of the appropriate nitrogen-fixing bacteria were added to the legume seed. The seed and soil mixture was uniformly broadcast by hand over the soil surface. The seeded soil was hand-raked and then firmed with a culti-packer. To help avoid border effects, the plots were sown without intervening alleys. The forage species were sown in pure stands without a nurse crop.

Planting methods used in establishing the strip-plots were, in general, similar to those used on New York

farms. Oats were used as the nurse crop. Two to 3 forage species were sown in mixture with oats. At 2 of 6 locations, the forage seeds were drilled with the oats; at the other 4 locations, the seeds were broadcast on the soil after oats had been sown. After seeding, some of the fields were rolled with a culti-packer. The strip-plots varied from 1 drill-width at some locations to 3 drill-widths at others, and their length varied from 100–1000 ft. The strip-plots were not replicated.

Obtaining data.—Extensive seedling-stand data were recorded 5–7 weeks after the plots were established. Hay yields were obtained from the 1950 and 1951 plantings only.

The density of the seedling stands in all field plots was measured in essentially the same manner. A wire frame, 3 ft. in length and 1 ft. wide, was divided into 3 parts, each 1 ft. square. This measuring frame was dropped at random at different places in each plot, and seedlings inside the frame were counted and recorded separately for each sq. ft. Where mixtures of forage seed were planted, the stand data were recorded separately for each species. Three samples totaling 9 sq. ft. were obtained from each of the randomized split- or sub-plots. The number of samples obtained in the larger strip-plots depended upon the plot length; 10 samples about equidistant apart were obtained from plots 100 ft. in length and 20 from those 1000 ft. long. Thus, a total of 30 sq. ft. comprised the sample in the smaller strip-plot and 60 sq. ft. in the larger.

The counting crews were comprised mostly of graduate students trained to recognize seedlings of the forage species used in the experiments. Since the plots were identified by numbers, the members of the counting crews were unaware of the nature of treatments used on seed in the different plots.

Weeds that grew in the plots were readily distinguishable from the forage species, but they slowed the work of counting. Plants that interfered with counting, including the oats used as a nurse crop and weeds, were clipped from the sampled areas.

Yields of hay were obtained and measured by means of methods commonly used in hay yield tests. A small power mower was used to cut a sample swath, 3 1/6 ft. $\times$ 16 5/6 ft., from each sub-plot in the randomized split-plot tests. Data on green weight were procured at harvest and dry weight and percentage dry matter were obtained later from an oven-dried sample. Sudan grass yields were determined in the first growing season, and yields of the perennial forages were obtained during the second growing season.

Data concerning seedling stands and hay yields were analyzed by means of the analysis of variance method.

Field plot sites.—The forage legume and grass seed-treatment experiments were performed on 6 different soil types that provided for much variation in the soil environment. The soil types comprised 2 gravelly loams (Volusia and Chenango), 3 silty clay loams (Dunkirk, Mardin, and Wayland) and 1 shaly loam (Phelps). Drainage of the Volusia and Wayland soils is poor, and they therefore tend to be wet and cold. Drainage of the other 4 types varied from fair to good, their temperature characteristics tending to range from cool to warm.

Natural fertility levels of the different soils ranged from fair to high. Since 250–400 lb. of complete fertilizers were applied per acre before seeding at all sites, it is likely that the levels of fertility were satisfactory for establishment of the different forage species. The randomized split-plots on the experimental farms at Ithaca, New York, were fertilized with 6-12-6 formulation. Strip-plots established in Oswego, Otsego, Steuben, Tompkins, and Wyoming counties were fertilized respectively with 8-8-8, 5-10-5, 6-12-6, 8-16-16, and 3-12-6 formulations.

With 1 exception, 1 ton of lime per acre was applied shortly before seeding on all plot sites. Two tons per acre were applied on the Steuben County plots because the soil was quite acid.

Land on which the randomized split-plots were established was generally level and, with 1 exception, the same was true for lands on which the strip-plots in outlying counties were planted. A very gradual slope at a right angle to the long axis of the entire strip plot existed at the Wyoming County site. This feature definitely influenced drainage of soil water and clearly affected seedling stands.

The diversity of prior farm crops on the lands used for the seed-treatment experiments gave assurance of normal complements of soil microflora. Apparently the microflora included plant pathogens, because some seedlings in many parts of all the established plots damped-off.

Rainfall and temperature.—Rainfall and temperature data were obtained for a period extending from 2 weeks before to 3–4 weeks after planting. Data were obtained for each of the 4 years from the records of weather stations located near but not at the experimental plots (Table 1). Rainfall within this critical period for seed rot and damping-off was lowest in 1951 and highest in 1953. The data indicate that soil moisture was favorable for seed rot and damping-off during the 4-week postplanting period at 7 of the 9 locations. Especially significant are the frequencies of rainfall at 7 of the locations during the postplanting period when damping-off and seed rot are most likely to develop.

Soil temperatures in the seed-treatment plots were not recorded, but air temperatures were obtained for both the preplanting and postplanting periods. The data on air temperatures suggest that soil temperatures were not inhibitive to organisms that cause seed rot and damping-off.

Results.—Data accumulated from 4 years of experimental work on forage legume and grass seed treatment are reported in condensed form to facilitate comparison of the results from different treatments.

In the replicated randomized seed-treatment plots established on the experiment station farms, wide

TABLE 1.—*Precipitation and air temperature near seed-treatment plots established near Ithaca and in outlying New York counties*

Year	Location	Date seeded	Precipitation during indicated period[a] 14 days prior to seeding	28 days after seeding	No. days with rainfall in 28-day post-seeding period	Average maximum air temperature during indicated period 14 days prior to seeding	21 days after seeding
			in.	in.		°F	°F
1950	Ithaca	June 8, 9	2.57	3.12	13	72.2	75.3
1951	Ithaca	May 1, 3	0.91	1.49	9	57.5	67.5
1952	Ithaca	May 1, 5	0.30	4.54	12	66.4	63.4
1953	(Counties)						
	Oswego	May 12	2.29	3.20	16	59.2	62.5
	Otsego	May 7	3.42	3.30	13	62.1	71.0
	Steuben	May 28	2.20	1.66	8	72.5	75.0
	Tompkins[b]	May 23	1.43	3.13	13	73.6	68.7
	Wyoming	June 3	2.23	1.87	11	61.5	74.8

[a] The periods for 1950, 1951, and 1952 are based on the first seeding dates listed.
[b] Data recorded at the weather station at Ithaca, New York.

variation in seedling stands was found among replicates of the same treatment. Actual stand differences of 100 per cent or more commonly occurred among replicated plots of the same treatment. Coefficients of variation attest to this observation (Table 2). Despite such wide differences among replicates of the same treatment, the mean differences among treatments were consistently small and they were not significant

TABLE 2.—*Summary of results obtained in forage legume and grass seed-treatment experiments performed in different years on replicated randomized split-plots*[a]

Variety[b]	Treatment	Mean number of seedlings/sq. ft.[c] 1950 Ketola	1950 McGowan	1951 Tailby	1951 McGowan	1952 Ketola
Ranger alfalfa	None	22.9	20.2	28.9	22.9	12.0
	Phygon	22.0	21.1	29.8	21.4	12.6
	Arasan	19.7	20.5	30.3	22.4	12.4
Narragansett alfalfa	None	17.4	18.3			
	Phygon	19.3	19.2			
	Arasan	19.4	20.9			
Kenland red clover	None	16.8	16.3	20.7	13.8	15.0
	Phygon	12.9	16.4	21.5	15.4	15.6
	Arasan	14.7	17.4	21.9	15.4	17.0
Empire birdsfoot trefoil	None	13.9	15.2	20.3	14.6	9.6
	Phygon	15.3	15.0	18.6	12.1	9.5
	Arasan	15.1	14.0	20.3	14.2	8.8
Viking birdsfoot trefoil	None	15.7	17.3			
	Phygon	17.8	16.8			
	Arasan	15.6	18.8			
Lincoln bromegrass	None	15.4	15.9	23.6	17.8	19.7
	Phygon	21.5	13.7	24.6	19.7	19.8
	Arasan	20.9	14.9	21.1	17.9	18.2
Canadian common bromegrass	None	15.3	12.5			
	Phygon	15.8	12.5			
	Arasan	15.6	11.8			
Timothy	None	83.1	44.4	40.3	43.7	49.3
	Phygon	73.1	46.1	35.3	35.3	48.1
	Arasan	78.6	48.8	34.8	41.0	45.3
Common orchard grass	None	17.5	12.5	19.9	19.2	21.4
	Phygon	18.3	12.6	22.1	23.0	21.0
	Arasan	18.8	15.6	20.1	21.1	20.5
Sudan grass	None	15.1	16.5	14.0	10.8	6.8
	Phygon	15.0	15.3	13.6	12.8	7.5
	Arasan	15.3	15.6	16.4	12.4	6.0
Coefficient of variation		20.1%	18.4%	17.3%	18.9%	29.2%

[a] Forages planted in pure stands without a nurse crop.
[b] Common timothy used in 1950 and 1952; Milton timothy used in 1951. California #23 Sudan grass was used in 1950 and Piper Sudan in 1951 and 1952.
[c] All differences among treatment means were not significant mathematically. Multiply mean number by 54 to find total seedlings counted in 6 replicates. Planting dates on different experiment station farms: 1950, June 8 and 9; 1951, May 1 and 3; 1952, May 1.

TABLE 3.—*Frequency of first-rank places gained by treated and untreated seed of 7 forage crop species planted in field plots in each of 3 years*

Forage species	Number of first-rank places by years[a]								
	1950			1951			1952		
	None	Phygon	Arasan	None	Phygon	Arasan	None	Phygon	Arasan
Alfalfa	4	5	3	5	3	4	3	2	1
Red clover	7	1	4	3	5	4	2	2	2
Birdsfoot trefoil	2	7	3	6	2	5	3	2	2
Timothy	4	3	5	5	2	5	2	2	2
Bromegrass	6	4	3	4	6	2	3	2	1
Orchard grass	5	3	3	3	7	7	2	2	2
Sudan grass	6	3	3	2	5	6	2	3	1
Total	34	26	24	28	30	33	17	15	11
Grand totals	No treatment, 79; Phygon, 71; Arasan, 68.								

[a] When seedling stands from treated and untreated seed tied for first, each was credited with a first-rank place.

as determined by the analysis of variance. Thus, the data show that seedling stands from untreated seed were equal to those produced by seed that was treated either with Arasan or with Phygon. Worthy of note is the fact that mean stand differences for timothy (Table 2) favored untreated seed but these differences also were not significant.

The number of times that each treatment ranked first in the randomized split-plot tests is of some significance (Table 3). Of 218 total first places (totaling those for all species and experiments), untreated seed ranked first 79 times, Phygon-treated seed 71 times, and Arasan treated seed 68 times. In general, first-rank places were similarly distributed among the treatments for each forage species. This equitable distribution clearly indicates that the rank attained by each treatment at any given time and place was a matter of chance and was not dependent on treatment.

Results obtained from the strip-plot tests, wherein the forages were sown with a nurse crop, were similar to those from the split-plot tests where a nurse crop was not used (Table 4). Differences in seedling stands among samples within a single treatment frequently were much greater than the differences among different treatments. Mathematically significant differences among treatments occurred only in seedling stands in Otsego and Wyoming county plots; however, these differences were caused by factors other than treatment of the seed. At Otsego, Phygon-treated alfalfa seed produced a significantly greater stand than did Arasan-treated or untreated seed. This result is doubtlessly erroneous, because in the strip-plot planted with Phygon-treated alfalfa seed there

TABLE 4.—*Summary of results obtained in forage seed-treatment experiments performed on strip-plots on farms in 5 New York counties*

Forage species	Treatment	Mean number of seedlings/sq. ft.[a]					
		Oswego	Otsego	Steuben	Tompkins		Wyoming
		1953	1953	1953	1952	1953	1953
Alfalfa	None						5.13
	Arasan	8.4	10.7	18.5			6.66
	Orthocide						8.01
	Phygon	12.2	15.2	15.7			8.61
	None	14.7	10.8	18.2			9.25
Red clover	Arasan			22.6	22.5	8.3	
	Orthocide				25.9		
	Phygon			19.8	24.3	8.6	
	None			23.5	24.5	10.4	
Bromegrass	None						1.80
	Arasan	11.6	16.0				2.71
	Orthocide						3.36
	Phygon	7.7	15.2				4.15
	None	13.2	17.3				3.56
Timothy	Arasan				43.1	77.5	
	Orthocide				56.0		
	Phygon				49.4	95.1	
	None				51.9	102.6	
Ladino clover	None						1.40
	Arasan				18.8		1.48
	Orthocide						2.03
	Phygon				19.4		1.31
	None				22.8		1.86

[a] There were no significant differences due to treatment among the mean numbers of seedlings.

were several spots where the drill failed to seed oats, and the alfalfa seedlings were more dense in these spots. Since the seedling stands were sampled at regular intervals, some of the sampled areas coincided with the oat-free areas thickly populated with alfalfa seedlings. The consequent increased number of seedlings found in the counted samples in the plot planted with Phygon-treated seed accounted for the high mean, which was significant over those of the other treatments.

Alfalfa, bromegrass, and Ladino clover constituted the forage mixture in the Wyoming county plots, and seedling stands were much lower than those of the same species grown at other locations (Table 4). The rates of seeding used in the Wyoming plots were much lower than those used for the same species planted at the other locations. Also, the Wyoming plots were sown from 1 to almost 4 weeks later than were plots at other locations. Since damping-off has been shown to be more destructive to alfalfa in warm moist soil than in cold moist soil, the disease was probably favored by the late date of seeding and helped to lower alfalfa stands in the Wyoming county plots.

As mentioned before, the layout of the Wyoming county strip-plots influenced soil moisture and this factor affected seedling stands in the different plots. At this location 2 strip-plots were planted with untreated seed to serve as checks, and they bordered the group of 3 strip-plots that were planted with treated seed. One check plot lay on the uphill side of the plots planted with treated seed and 1 on the downhill side. Movement of soil moisture was at right angles to the long axis of the plots so that soil moisture varied from low and deficient in the check plot on the uphill side to moderately high and adequate in the check on the downhill side. The layout of the plots was as follows: Uphill check, Arasan, Orthocide 75, Phygon, and downhill check. The mean number of alfalfa seedlings per sq. ft. was lowest in the uphill check, and the mean number increased gradually in the different plots to a high point in the downhill check (Table 4). Seedling stands of alfalfa in the downhill check, Phygon, and Orthocide plots were significantly greater than those in the Arasan and uphill check plots. Mean stand differences among Orthocide 75, Phygon, and downhill check were not significant, and the difference between the uphill check and Arasan was not significant. Thus, the trend of the data indicates that mean seedling stand differences encountered in the Wyoming county plots were caused by variation in field conditions and not by seed treatment.

Results from the bromegrass and Ladino clover seed treatments in the Wyoming plots paralleled those for alfalfa (Table 4).

Data discussed before show that forage legume and grass seed treated with fungicides did not produce larger initial stands than did some of the same seed untreated. It was conceivable, however, that the fungicides might produce a latent effect because of their action on some seed-harbored organisms that might slowly reduce the stands. An effort was made, therefore, to determine the mean number of seedlings per sq. ft. after the forage plants had been established about 1 year. Stand counts were made, as described before, in the forage legume plots that were established in 1950 on the McGowan farm. Stand counts were not made in the 1-year-old grass plots because the expense of doing so was prohibitive. Results from several plots of each legume show that, in 1 year, stand reductions of alfalfa ranged from 4 to nearly 40 per cent, red clover 10 to 14, and birdsfoot trefoil from 15 to 27 per cent (Table 5). More important is the fact that legume stands from untreated seed were not reduced more than were those from treated seed. As a matter of fact, the stand reductions in plots from untreated seed usually were smaller than those from treated seed. Whatever the factor or factors responsible

TABLE 5.—*Comparison of 1-year-old forage legume stands with initial stands in the same field plots planted with treated or with untreated seed, McGowan Farm, Ithaca, N. Y.*[a]

Variety	Treatment	Mean number of plants/sq. ft. 1950	Mean number of plants/sq. ft. 1951	Decrease in plants/sq. ft. during 1 year
				per cent
Ranger alfalfa	None	20.2	12.5	38.1
	Arasan	20.5	14.4	29.7
	Phygon	21.1	13.8	34.5
Narragansett alfalfa	None	17.6	16.9	3.9
	Arasan	20.9	17.3	17.2
	Phygon	19.2	17.1	10.9
Kenland red clover	None	16.3	14.6	10.4
	Arasan	17.4	14.9	14.3
	Phygon	16.4	14.1	14.0
Empire birdsfoot trefoil	None	15.2	12.4	18.4
	Arasan	14.3	12.2	14.6
	Phygon	15.0	11.0	26.6
Viking birdsfoot trefoil	None	17.3	13.4	17.3
	Arasan	18.8	13.7	27.1
	Phygon	16.8	13.0	22.6
Coefficient of variation			15.4%	

[a] Plots seeded June 9, 1950; 1950 data obtained July 8–14; 1951 data obtained July 9–17.

for reduction of legume stands on the McGowan plots, it is at least apparent that there was no latent beneficial effect of the seed-treatment chemicals in the first year after seeding.

When the forage legume and grass seedlings were 4–6 weeks old, there were no observable differences in vigor that could be correlated with seed treatment. It was conceivable, however, that seedlings from treated seed might establish better root systems than those from untreated seed and that such a difference eventually might be reflected in hay yield. Yields were obtained, therefore, from plots that were established on the experiment station farms in 1950 and 1951.

Yield data obtained from plots established in 1950 and 1951 showed large differences among the replicates of a single treatment for a given forage species. Such differences were often much greater than differences between treatments. Yield differences among treatments were not significant statistically (Table 6). Yields from plots established in 1951 were generally lower than those from plots established in 1950, but like the latter, there were no significant differences in yield caused by seed treatment.

Discussion.—The foregoing results show that the treatment of small-seeded legume and grass seed with fungicides was not beneficial. Seedling stands and hay yields of several important forages produced from untreated seed were equal to those produced from seed treated with well known fungicides. The importance of these results is enhanced by the fact that they were obtained from field experiments performed on a reasonably extensive scale during a period of 4 years. Treated and untreated seed were exposed to methods of culture that closely approximated some of those practiced on farms. The experiments were performed on soils of different types, on soils with different cropping histories, and under conditions of variable soil moisture, temperature, and fertility. Furthermore, the ubiquity of seed-rotting and damping-off fungi in arable soils suggests that they were present and active in at least some of the environments

Table 6.—*Summary of hay yields obtained from field plots planted with treated or untreated forage legume and grass seed*[a]

Variety[b]	Treatment	Mean yields, tons/acre[c] 1950 seeding		1951 seeding	
		McGowan	Ketola	McGowan	Tailby
Ranger alfalfa	None	1.60	1.01	0.49	[d]
	Arasan	1.56	0.95	0.45	
	Phygon	1.55	1.06	0.38	
Narragansett alfalfa	None	1.89	1.22		
	Arasan	1.97	1.32		
	Phygon	2.01	1.39		
Kenland red clover	None	2.43	1.61	1.00	[d]
	Arasan	2.28	1.53	1.04	
	Phygon	2.28	1.56	1.08	
Empire birdsfoot trefoil	None	1.47	0.60	0.89	0.53
	Arasan	1.48	0.65	0.78	0.54
	Phygon	1.33	0.65	0.79	0.65
Viking birdsfoot trefoil	None	1.42	0.94		
	Arasan	1.39	0.87		
	Phygon	1.39	0.82		
Lincoln bromegrass	None	3.38	1.26	1.88	1.26
	Arasan	3.22	1.34	1.88	1.19
	Phygon	3.54	1.29	1.89	1.24
Canadian common bromegrass	None	2.30	0.77		
	Arasan	2.51	0.84		
	Phygon	2.47	0.72		
Timothy	None	2.95	1.55	1.51	1.06
	Arasan	2.86	1.36	1.56	0.94
	Phygon	2.85	1.30	1.54	0.99
Common orchard grass	None	3.23	1.75	1.54	0.98
	Arasan	3.37	1.58	1.60	0.98
	Phygon	3.27	1.68	1.54	0.96
Sudan grass	None	2.18	[d]	2.01	1.77
	Arasan	2.18		2.11	1.81
	Phygon	2.17		2.06	1.95
Coefficient of variation					
Sudan grass		11.1%		13.3%	12.3%
Perennials		10.0%	12.2%	12.8%	14.5%

[a] 1950 seedings: 1 cut of perennial species on June 18, 1951; 1 cut of Sudan grass on August 8, 1950. 1951 seedings: 1 cut of perennial species on June 18, 1952; 2 cuts of Sudan grass, 1 on July 26, 1951, and 1 on September 7, 1951, 2 cuts totaled.

[b] Common timothy was used in 1950 and Milton timothy in 1951; California #23 Sudan grass was used in 1950 and Piper Sudan in 1951.

[c] Differences among means were not significant.

[d] Not harvested because of damage by rodents, deer, or weeds.

where treated and untreated seeds were exposed. Despite this, treatment of seeds with fungicides persistently failed to increase stands and yields of the forage species used. Treatment of forage seed with the fungicides did not significantly reduce seedling stands and yields below those from untreated seed.

In the light of the results presented, the fungicidal treatment of small-seeded forage legume and grass seed offers little if any promise of benefits to the New York grower making spring plantings. Justifiable exceptions should be noted however. For example, it has been shown that some smut fungi that attack grasses can be controlled by appropriate seed-treatment chemicals (9). Where the smut diseases of grasses are real problems, therefore, seed treatment should be practiced. A special case also can be made for Sudan grass. Seed of this forage commonly harbors destructive plant pathogens that can be controlled, in part at least, by seed treatment (17).

Whereas the use of low quality forage seed should not be practiced, situations arise where the use of such seed cannot be avoided. Kernkamp (15) has pointed out that mechanically injured forage seed, particularly alfalfa, should be treated to improve emergence.

As noted before, published results indicate that suitable seed-treatment chemicals partially control seed-rot and damping-off in some greenhouse-grown forage legume and grass plantings. Because these diseases can be very destructive to forages in greenhouse plantings, widespread belief arose that they occur equally as destructively in field plantings. It was assumed that since some seed-treatment chemicals sometimes improved seedling stands of greenhouse-grown forages, they would do likewise in commercial farm plantings. The results of the extensive field tests reported in this paper do not justify this assumption. Either seed rot and damping-off are not normally destructive in field cultures of small-seeded legumes and grasses, rendering seed-treatment chemicals unnecessary, or they are destructive, and the seed protectants employed in these experiments are useless for combating them in farm plantings established during spring and early summer in New York.

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PATHOGENICITY OF SPECIES OF HELMINTHOSPORIUM FROM BRAZILIAN OATS [1]

Martin Tveit [2]

SUMMARY

In isolations from different lots of oat seed from Brazil, *Helminthosporium victoriae* and *H. avenae* were obtained frequently, and *H. pedicellatum* occasionally. Judged by pathogenicity on 8 varieties of oats grown in the greenhouse, both *H. victoriae* and *H. avenae* comprise a number of different and distinct parasitic races. One race of *H. victoriae* isolated from Brazilian oats was just as virulent on Vicland oats as the most virulent race found on naturally infected Vicland oats grown at St. Paul, Minnesota. Several races of *H. victoriae* from Brazilian oats were at least moderately pathogenic on several varieties of oats of non-Victoria parentage. There were no clear cut and consistent differences in range of pathogenicity among isolates of *H. victoriae* and those of *H. avenae* on 8 varieties of oats. The variety Andrew was immune to all isolates tested to the 3 species of *Helminthosporium*. *H. pedicellatum* was weakly pathogenic on oats. The possibility is suggested that *H. victoriae* may have been introduced into the United States from Brazil on seed of Victoria or similar varieties of oats.

Victoria blight of oats was first described in 1946, and the fungus causing it was designated as a new species, *H. victoriae* Meehan & Murphy (5). The sudden appearance of this disease and its subsequent destructiveness on certain oat varieties gave rise to much speculation as to the origin of the disease and the taxonomic relationships of the fungus.

It has been demonstrated that considerable range in parasitism and in various other physiological characters exists within individual species of *Helminthosporium* that attack cereal plants (1, 2, 3). Whether a similar range in parasitism occurs within *H. victoriae* is not known. Supposedly, *H. avenae* Eidam and *H. victoriae* differ in parasitism. This supposed distinction, however, is based on studies of only a small number of isolates, and the question as to the validity of this distinction remains open.

During the course of studies on *Helminthosporium* spp. on oats in Minnesota, 21 samples of seed were obtained from Brazil. *H. avenae* and *H. victoriae* were isolated from seed with considerable frequency. Therefore, studies were made to determine the range of variation in cultural characters and pathogenicity among the biotypes or races of these 2 species of *Helminthosporium*. Attempts also were made to ascertain if *H. victoriae* was introduced into the United States on oats seed from Brazil.

MATERIALS AND METHODS.—*Isolation and identification of Helminthosporium spp.*—Twenty-one samples of oat seed were obtained from unknown locations in Brazil in the fall of 1950. Thirty seeds of each sample were immersed for 3 minutes in a 1:1000 solution of mercuric bichloride, then for 2 minutes in a 0.5 per cent solution of sodium hypochlorite. They were then washed in sterile distilled water, placed on acid potato-dextrose agar in petri dishes, and incubated for 1–2 weeks at room temperature (22–24°C).

Those cultures of Helminthosporium that were identifiable on the basis of spore characteristics were transferred to test tube slants for stock cultures, and these were used in the pathogenicity tests. All of the isolates used in any of the tests originated from hyphal tips that were cut off with a microrazor.

Preparation and application of inoculum.—The isolates used in tests for pathogenicity were grown for 5–10 days in 100 ml of potato-dextrose broth in 250-ml flasks. Just prior to inoculation, the fungus mats from 2 or more replicate flasks were placed in an autoclaved Waring Blendor, and 400 ml of sterile water was added for each mat. The blender was run for 1 minute.

One hundred ml of the suspension of mycelium in water was added to each 4-in. pot of autoclaved soil at seed level. The seeds were added and covered with 1 in. of autoclaved soil. All pots had been autoclaved just before use. Only seed from high grade lots known to be free of Helminthosporium was used. The fact that noninoculated checks did not develop the disease attests that the seed was free of this pathogen. To avoid further contamination, the soil in greenhouse benches, on which the pots were placed, was disinfested with a 1:300 solution of formaldehyde. Notes were taken on total emergence and when the plants were in the 3–4 leaf stage, records were taken on the number of blighted seedlings and the degree of discoloration or necrosis of the mesocotyls.

RESULTS.—*Species of Helminthosporium isolated from Brazilian oats.*—One hundred sixty-seven colonies of Helminthosporium were obtained from the seeds cultured, and 127 were identified. Of these, 56 were *H. victoriae*, 5 were *H. pedicellatum* Henry, 49 were *H. avenae*, and 17 resembled *H. avenae* except for a distinctly pink to red coloration.

Pathogenicity.—Eighty-five of the isolates were test-

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TABLE 1.—*Pathogenicity of Helminthosporium victoriae, H. avenae (gray and pink), and H. pedicellatum isolated from Brazilian oats, based on average emergence and degree of blighting of leaves and mesocotyls of Vicland and Clinton oats*

Pathogen	Race	Frequency of isolation	Infection rating on[a] Vicland	Clinton
H. victoriae	1	4	8	3
	2	1	7	3
	3	12	6	2
	4	10	3	2
	5	13	1	1
H. avenae (gray)	1	12	4	3
	2	10	3	2
	3	8	1	1
H. avenae (pink)	1	4	4	3
	2	2	3	3
	3	4	1	0
H. pedicellatum		5	2	1
Check			1	1

[a] Infection rating is based on a scale of 1 to 10, with 1 as the least virulent and 10 the most virulent.

ed for pathogenicity on Vicland and Clinton oats. Pathogenicity of the isolates was rated on a scale of 1 to 10 on the basis of numbers of seedlings that emerged and numbers of blighted leaves and mesocotyls, with 1 as the least virulent and 10 the most virulent. On the basis of the results of these tests, 40 of the 56 isolates of *H. victoriae* from Brazilian oats were divided into 5 pathogenic races as listed in Table 1 and illustrated in Figure 1. These classes were based on the experimental results obtained and obviously could be subject to change on the basis of further studies.

The 30 gray isolates of *H. avenae* fell into 3 groups, on the basis of pathogenicity on Vicland and Clinton oats. Twelve of the isolates damaged the mesocotyls of Vicland oats severely and caused only slightly less damage to Clinton. The 10 pink isolates of *H. avenae* that were tested behaved similarly to those of the typical gray isolates of *H. avenae*. A number of races of *H. avenae* also were obtained from Brazilian oats.

FIG. 1. Five groups of seedlings of Vicland oats illustrating 5 degrees of pathogenicity of *Helminthosporium victoriae*. Most pathogenic on the left, least on the right. Typical stands from 15 seeds.

Vicland, Clinton, Bonda, and Gopher oats were inoculated in greenhouses maintained at approximately 18° and at 30°C. Race 1 of *H. victoriae* from Brazil was as virulent as H-67, the most pathogenic isolate from Minnesota. Both were somewhat more pathogenic at 30° than at 18°. Pathogenically, race 1 from Brazil and H-67 from Minnesota appear to be very similar.

None of the races of *H. victoriae* caused pre-emergence killing of plants of Clinton, Bonda, or Gopher oats (Table 2). It would appear, therefore, that these varieties are highly resistant to all of the isolates and races of *H. victoriae* tested. At 30°C, the degree of mesocotyl browning was slightly greater on Gopher than on the other varieties, hence Gopher appears slightly less resistant than does Clinton or Bonda to *H. victoriae*.

Eight varieties of oats were inoculated with 15 of the gray isolates and 8 of the pink isolates of *H. avenae*, with races 1, 2, and 3 of *H. victoriae*, and with 1 isolate of *H. pedicellatum*. The pots were kept at approximately 22°C from the time of planting until notes were recorded (Table 3).

Isolates 2 and 3 of *H. avenae* were highly virulent on Vicland, Tama, Nakota, Ajax, and Zephyr, and only slightly less virulent on Bonda and James, whereas isolate 1 was distinctly less virulent on Bonda. Isolates 14 and 15 caused minor lesions on only a few plants, and thus were only very weakly pathogenic. None of the pink isolates of *H. avenae* were as pathogenic as the most pathogenic gray isolates of *H. avenae*. Other than that, there was about the same range among the pink isolates as among the typically colored isolates of *H. avenae*, and it seems likely that the major difference between the 2 groups is one of colony color only.

Race 1 of *H. victoriae* was more pathogenic than

TABLE 2.—*The pathogenicity of Helminthosporium avenae (gray), H. pedicellatum, and 3 races of H. victoriae in Vicland, Clinton, Bonda, and Gopher oats at 18° and 30°C in the greenhouse*

	Infection rating[a]							
	Vicland		Clinton		Bonda		Gopher	
Pathogen	18°	30°	18°	30°	18°	30°	18°	30°
H. victoriae[b]								
race 1	1	2	7	8	8	8	8	9
race 2	7	4	8	8	7	8	7	8
race 3	8	7	6	7	6	7	6	7
H-67	3	1	8	8	7	8	8	9
H. avenae (gray)	10	10	9	8	7	9	8	8
H. pedicellatum	10	8	6	7	6	7	6	6
Check	6	6	6	6	6	6	6	6

[a] Infection rating is based on a scale of 1 to 10, with 1 the least virulent and 10 the most virulent.

[b] Races 1, 2, and 3 from Brazil; H-67 from Minnesota.

TABLE 3.—*Pathogenicity of Helminthosporium avenae, H. victoriae and H. pedicellatum, as measured by mesocotyl blighting in 8 varieties of oats grown in infested soil*

Kind of inoculum	Number of plants with blighted mesocotyl from 2 replicates of 30 seeds each[a]							
	Vicland	Tama	Nakota	Ajax	Zephyr	Bonda	Andrew	James
H. avenae (gray)								
Isolate 1	48	39	50	50	47	4	0	16
2	40	36	49	50	30	42	0	16
3	50	36	45	40	44	33	0	30
4	34	17	32	30	24	17	0	27
5	9	11	25	32	28	17	0	26
6	17	20	14	26	19	12	0	19
7	23	30	24	19	6	4	0	11
8	17	24	17	9	11	12	0	10
9	17	16	25	11	9	0	0	19
10	19	26	12	9	7	0	0	15
11	11	16	13	6	6	0	0	11
12	16	19	15	0	0	0	0	3
13	9	11	13	6	0	0	0	0
14	5	0	4	0	0	0	0	0
15	0	4	8	0	0	0	0	4
Check	0	0	8	0	0	0	0	0
H. avenae (pink)								
Isolate 1	23	11	9	8	15	6	0	14
2	19	22	15	9	13	6	0	9
3	19	23	17	12	9	4	0	4
4	13	29	19	6	2	0	0	3
5	11	9	9	7	0	0	0	9
6	7	4	3	0	3	0	0	7
7	3	5	4	0	0	0	0	7
8	0	4	6	1	0	0	0	6
H. victoriae								
Race 1	100	100	100	16	13	8	0	14
2	32	27	29	19	11	7	0	11
3	12	9	14	6	0	0	0	9
H. pedicellatum	11	7	10	0	0	0	0	7
Check	0	0	8	0	0	0	0	6

[a] Emergence was essentially the same in all tests, and was approximately 57 plants for the 2 replicates, except in the case of race 1 of *H. victoriae* on Vicland, Tama, and Nakota, where the stand was greatly reduced.

races 2 and 3, and more pathogenic than any of the isolates of the other species of *Helminthosporium* tested. The 3 races of *H. victoriae* differed as much and as consistently among themselves in this test as in the previous tests, and thus seem to be definite and distinct parasitic races. Despite the facts that Ajax and Bonda were highly resistant to all 3 races of *H. victoriae* and Andrew was immune, race 1 caused temporary stunting of all of these varieties. The stunted seedlings recovered later and became normal in appearance. The cause of the temporary stunting was not determined.

The single isolate of *H. pedicellatum* tested on 8 varieties was slightly pathogenic on Vicland, Tama, Nakota, and James varieties, but the other 4 varieties were not infected by it.

DISCUSSION AND CONCLUSIONS.—*H. victoriae* has been known in the field in North America only since 1945. Some investigators have thought that prior to 1945 it probably was endemic on wild or cultivated grasses, and that it became prevalent and destructive only after susceptible varieties of oats with Victoria parentage were introduced and widely grown. The fungus was not reported as occurring in South America. Certainly, Victoria blight has not been either common or destructive in South America, although the variety Victoria is of South American origin, and the Victoria-type varieties are common there. One of the principal varieties of Brazil, Ascencao, is known by previous tests by M. B. Moore (unpublished) to be susceptible to *H. victoriae*.

The evidence presented here indicates that pathogenic races of *H. victoriae* are not uncommon in oat seed from Brazil. At least 1 race from Brazil is as virulent on Vicland oats as the most pathogenic isolate from Minnesota (4). Since the virulent races of the fungus are present there, and susceptible varieties of oats are grown widely, it is difficult to account for the absence or near-absence of Victoria blight. One possible explanation is that the antibiotic action of *Chaetomium spp.* reported by Tveit and Moore (6) actually is effective in preventing widespread or damaging disease.

It is possible that the sudden outbreak of Victoria blight in the United States may have resulted from the importation of strains and races of *H. victoriae* on breeding material. Once established in the seed stocks, and possibly in the absence of biological con-

trol, the fungus may have increased quickly, spread rapidly, and caused destructive epidemics.

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THE RESPONSE OF OAT STRAINS TO SEPTORIA AVENAE [1]

Steve Lund and H. L. Shands [2]

SUMMARY

About 3500 strains of the World Oat Collection were inoculated with a mycelial suspension of *Septoria avenae* in the field in 1951.

Approximately 250 strains were selected as being sufficiently resistant and of enough agronomic interest to warrant retesting in 1952 and 1953. No line was immune, but many were found to be as resistant or more resistant to the isolates used than was the resistant check, Clintafe. Most of the more resistant varieties were late for heading and maturity.

Septoria disease of oats caused by *Septoria avenae* Frank, the imperfect stage of *Leptosphaeria avenaria* G. F. Weber, has become of increasing importance in the spring oat areas of the United States. A rapid build-up of the disease was noted in Wisconsin in the late 1940's and reached epidemic proportions in some areas of the state by 1952. Hence, this study was initiated to find sources of resistance superior to that of the oat varieties in general use.

Weber (8) tested the reaction of several species of *Avena* and closely related genera to *Septoria avenae* and found all strains of the *Avena* species tested to be susceptible. Meehan and Murphy (4) obtained infection on 36 varieties of inoculated oats, but they did not report a differential response among varieties. In 1950, Poole (7), listed the reaction of oat varieties grown in the Iowa nursery, and Pendleton et al (5, 6) reported disease reactions of oat varieties grown in yield trials at Illinois during 1949 and 1952. These last reports were apparently the results of natural infection as no information on inoculation was reported. Goto (2) tested seedlings of 90 varieties and selections in 1952 and found some resistance but no immunity to Septoria. Derick (1) observed the response of a Canadian collection of oat varieties to natural infection of Septoria. Huffman (3) inoculated plants of 2 replications of 4751 entries in the World Oat Collection and chose for further testing 293 selections with less than 20 per cent leaf spot. He also tested the World Collection a second time and listed 23 selections that were more resistant to leaf spot than were commercial varieties.

MATERIALS AND METHODS.—In 1951, seed of some 3500 oat strains from the World Collection[3] of the United States Department of Agriculture was grown at Madison, Wisconsin. These strains were inoculated with *Septoria avenae* during the 1951 season. Data obtained in 1951 indicated that about 250 strains had sufficient disease resistance and agronomic desirability to warrant retesting.

In all 3 years, 4 culms of each strain were inoculated by hypodermic injection of a mycelial suspension of the fungus. An effort was made to select each culm from a different plant. The identity of the inoculated culms was maintained for later harvest.

A composite of several isolates obtained from the north central United States was used for the inoculum. Nonsporulating cultures grown on potato-dextrose agar

[1] Accepted for publication August 11, 1955.

[2] Formerly Graduate Assistant, University of Wisconsin, now Assistant Research Specialist, Rutgers University, New Brunswick, New Jersey; and Professor of Agronomy, University of Wisconsin, respectively.

[3] Seed was obtained from David J. Ward, Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland.

TABLE 1. *The 1951 heading date, percentage leaf spot from natural infection in 1952, and highest percentage of stem lesions in 1952 or 1953 of oat varieties from the World Collection which were more resistant to stem rot than was Clintafe when inoculated with Septoria avenae at Madison, Wisconsin*

Variety or C. I. number	Heading date 1951	Leaf spot 1952	Stem lesioning 1952-3	Variety or C. I. number	Heading date 1951	Leaf spot 1952	Stem lesioning 1952-3	Variety or C. I. number	Heading date 1951	Leaf spot 1952	Stem lesioning 1952-3
		%	%			%	%			%	%
Clarion[a]			61	2241	7/12	8	3	3469	7/5	15	2
Andrew[b]		39	27	2248	7/8	5	4	3471	6/21	5	2
Clintafe[a]		4	10	2254	7/12	3	2	3610	7/4	5	8
751	7/10	10	8	2268	7/9	3	3	3625	7/9	3	2
798	7/9	3	10	2327	6/28	10	5	3629	6/29	5	5
838	7/3	2	8	2386	7/10	3	1	3630	6/29	10	5
840-1	6/29	15	5	2387	7/9	2	2	3806	7/9	5	10
1090	7/9	10	8	2389	7/9	8	2	3822	7/5	8	8
1251	7/11	5	5	2415	7/12	5	1	3876	6/27	5	10
1268	7/11	5	5	2420	7/11	8	2	3888	6/27	5	10
1322	7/12	8	8	2445	7/13	2	5	3937	7/5	3	8
1340	7/10	2	2	2552	7/11	2	3	3941	7/5	8	6
1345	7/9	3	1	2556	6/28	15	8	3997	6/28	8	1
1384	7/10	2	5	2676	7/12	5	2	3999	6/26	10	5
1463	7/10	3	3	2680	7/4	5	2	4024	7/2	5	8
1468	7/9	15	5	2702	7/11	5	8	4055	6/30	1	10
1475	7/11	8	8	2703	7/11	10	8	4056	6/27	10	8
1506	7/11	10	1	2708	7/12	3	2	4076	7/11	2	3
1528	7/11	5	2	2723	6/27	5	10	4088	6/27	5	10
1588	7/10	2	5	2750	7/10	3	5	4095	7/5	2	5
1589	7/11	2	5	2752	7/12	2	5	4104	7/6	5	10
1591	7/9	3	2	2764	7/18	5	3	4144	6/29	5	5
1592	7/11	2	10	2765	6/28	8	5	4281	7/5	5	8
1649	7/11	3	2	2767	6/24	5	8	4330	6/27	10	10
1750	7/10	5	8	2827	7/9	8	5	4456	6/29	3	5
1809	7/10	5	5	2841	7/11	8	8	4477	6/30	8	5
1888	7/11	2	1	2857	7/11	8	3	4582	7/9	5	6
1913	6/27	15	10	2868	7/6	10	8	4597	7/12	2	5
1914	6/28	8	8	2885	6/30	5	8	4653	7/8	3	7
1923	7/4	1	1	2892	6/30	15	5	4656	7/8	2	2
1942	6/28	8	8	2903	6/28	8	10	4677	6/27	3	10
1957	7/9	5	2	2910	7/10	5	5	4713	7/11	5	2
1964	7/12	10	1	2911	7/2	5	5	4727	7/9	3	3
1972	7/11	5	8	2936	7/10	8	3	4761	7/5	3	5
1990	7/11	2	3	3032	7/10	2	5	4791	7/4	2	1
1991	7/11	8	5	3039	7/2	2	10	4792	7/3	8	4
2035	7/12	1	2	3071	7/4	8	7	4832	7/1	8	1
2043	6/25	8	10	3073	6/24	5	8	4998	7/11	5	5
2069	7/11	5	8	3126	7/4	2	2	5029	7/4	5	8
2077	7/10	5	3	3219	7/10	10	5	5065	7/1	8	2
2078	7/10	3	1	3253	6/29	15	8	5083	7/12	3	5
2100	6/25	10	8	3265	7/11	3	2	5303	6/30	10	8
2135	7/12	5	5	3266	6/25	8	5	5323	6/28	5	10
2173	7/11	5	1	3451	6/21	10	10	5327	7/4	8	8
2176	7/2	3	10	3463	7/10	3	8	5342	7/8	5	8
2197	7/9	3	5	3464	6/28	5	10	5343	7/9	3	5
2205	7/11	3	3	3467	6/28	10	8	174545[c]	7/20	1	3

[a] Average of 12 replications in 1953 test.
[b] Average of 8 replications in 1952 test.
[c] Refers to P. I. number.

were chopped in distilled water in a Waring Blendor for about 1 minute. The mixture then was strained through a single thickness of cheesecloth to remove the large particles. The suspensions were either used immediately or stored for a maximum of 2 days at 3°–5°C. Inoculations were made by injecting the suspension into the culm or leaf whorl of each plant by means of a 5- or 10-ml syringe fitted with a no. 20 needle.

In 1951, the inoculations were made over a 5-day period, regardless of the stage of development of the plants. In 1952 and 1953, however, the inoculations were made just prior to internode elongation. Previous tests had shown this to be the optimum stage for subsequently discerning varietal reaction to the disease.

The plants were harvested at maturity, and stem-infection readings made in the laboratory. These readings were made after removing the sheath and were based on the average infection of that portion of the culm adjacent to the inoculation center.

The leaf spot readings were made on plants naturally infected in the field and were based on the estimated amount of the leaf covered by the Septoria lesions.

RESULTS AND CONCLUSIONS. — Varieties that were more resistant than Clintafe when inoculated with the mixture of isolates of Septoria used at Wisconsin are listed in Table 1. The results indicated, as did the initial tests in 1951, that most of the late maturing varieties were relatively free of the disease. It was thought that many of these could have escaped infection because of their lateness. Subsequent tests, however, showed that many of the late varieties had a high degree of resistance when inoculated at the proper stage of maturity.

In many cases, seed lots were mixed, and most of these were not tested further. No attempt was made to separate the mixtures or to purify these lines. There is no doubt that some of the discarded lines may be as resistant as those listed in Table 1.

Many of the lines other than those mixed were discarded after the 1951 test because of lateness, excessive susceptibility to rusts, or other undesirable characteristics. Some of the lines discarded for these reasons may have a high degree of resistance to the Septoria disease.

The leaf spot readings given in Table 1 were taken following a rather severe natural infection which occurred in 1952. Earlier-heading lines of oats appeared more susceptible to this phase of the disease than later ones, but some of the very late lines did show a rather high percentage of leaf spot. It is noteworthy that there is only a low correlation between leaf spot and stem infections. A correlation coefficient of 0.231 was obtained on the 257 lines that received ratings for leaf spot and stem lesions in 1952. It was apparent in the field that some lines responded differently to these 2 phases of the disease.

The resistant check variety Clintafe appeared to be mixed for reaction to artificial inoculation with Septoria because readings varied widely. It had a rather high degree of resistance, however, for few severely infected stems were present. This was true not only in the present study but also in other observations made on the variety. The average stem readings on this variety in both 1952 and 1953 were 10 and 9.3, respectively.

For each strain other than the checks, the highest reading obtained in 1 of 2 years is given in Table 1. The readings are presented in this way to avoid overestimating resistance. In all cases, the readings in the other year were equal to or less than the reading presented in Table 1.

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PATHOGENICITY OF PSEUDOMONAS TABACI ON SOYBEANS AND TOBACCO [1]

Donald W. Chamberlain [2]

SUMMARY

Cross-inoculations with 6 isolates of *Pseudomonas tabaci* from tobacco and 6 from soybeans indicated strain differences in pathogenicity for either host. Tobacco isolates were consistently more pathogenic on tobacco than were the soybean isolates. On soybeans, the reverse was true, but differences were less pronounced. The erratic behavior of all isolates on soybeans indicated that *Ps. tabaci* is a less virulent primary parasite on soybeans than on tobacco.

Since it was first recognized in 1943, the wildfire disease of soybeans has aroused considerable speculation because 1) it does not spread from tobacco to soybeans and 2) it appears on soybeans in areas where no tobacco is grown. Allington (1) demonstrated that the wildfire organism on soybeans is morphologically and serologically identical with *Pseudomonas tabaci* (Wolf & Foster) Stevens, the tobacco wildfire organism. Clayton (4), however, was able to induce only slight wildfire on field soybeans by repeated artificial inoculations. It seemed possible that there might be strains of the organism differing in pathogenicity for the 2 hosts. Accordingly, a study of the comparative pathogenicity of isolates of *Ps. tabaci* from tobacco and soybeans was made on each of these hosts. An abstract covering part of this work has been published (2).

EXPERIMENTAL METHODS.—A total of 12 isolates, 6 from tobacco and 6 from soybeans, were tested. Single colony isolates were made as each culture was acquired. Since the tests were carried on over a period of 5 years, no single experiment involved all 12 isolates. Stock cultures were maintained in nutrient broth at 6°C. Each isolate was passed through its particular host once every 4–6 months to maintain pathogenicity. Any isolate showing a consistent loss in virulence through 3 successive inoculations on its original host was eliminated from further trials. The organism was grown in Wernham's buffered potato-dextrose broth for 4–5 days at 24°C, and then centrifuge-washed through 3 changes of sterilized distilled water to remove the toxin. The bacteria were then suspended in sterilized distilled water, and the turbidity was standardized at approximately 8×10^8 cells per ml. Inocula consisted of 1:100 dilutions of this standardized suspension.

The pathogenicity of each isolate was determined by the total number of halos produced, expressed as percentage of total inoculations. Havana No. 38 tobacco and the soybean varieties Lincoln, Illini, and Bansei were used. Tobacco and soybean isolates were compared on opposite halves of the same leaf on each host. The topmost fully developed soybean leaf was inoculated on 6–9 plants for each pair of isolates. On tobacco, since there was less variation in susceptibility between upper and lower leaves, 3–6 leaves on each of 4-6 plants were inoculated. Tobacco was usually inoculated by needle-puncture. Soybeans were inoculated by means of an atomizer powered by compressed air. Watersoaking of the leaves resulted. The 2 different inoculation methods were used because needle-puncture is usually ineffective on soybeans, whereas watersoaking of the tobacco leaf frequently results in large necrotic areas.

RESULTS.—Previous investigators have found considerable variation in pathogenicity among isolates of the wildfire organism from tobacco, and this was confirmed in the studies here reported. Typical results of cross-inoculations are shown in Table 1. On tobac-

TABLE 1.—*Pathogenicity of isolates of Pseudomonas tabaci on tobacco and soybean*

Isolate[a]	Host	Percentage infection[b] in 4 trials		
		Maximum	Minimum	Mean
S1	Soybean	94	0	45
	Tobacco	10	1	6
S2	Soybean	100	0	44
	Tobacco	19	0	6
S3	Soybean	50	4	12
	Tobacco	4	0	1
T1	Soybean	22	0	17
	Tobacco	97	72	91
T2	Soybean	61	0	19
	Tobacco	94	67	82
T3	Soybean	50	0	15
	Tobacco	82	50	70

[a] S1, S2, and S3 were soybean isolates; T1, T2, and T3 were tobacco isolates.

[b] Percentage of total inoculations that developed typical wildfire lesions.

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[2] Plant Pathologist, Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture. Grateful acknowledgment is made to Drs. E. E. Clayton, Stephen Diachun, Robert W. Fulton, H. E. Heggestad, and R. A. Kilpatrick for supplying cultures of the organism.

co, the isolates from tobacco were uniformly high in pathogenicity and the soybean isolates low; on soybean, the reverse was true. Significant differences consistently were found between soybean and tobacco isolates on tobacco; there was usually a difference on soybeans also, but it was not always statistically significant. Further, the reaction of any isolate on soybeans was extremely variable from 1 experiment to another. When a soybean and a tobacco isolate were compared on opposite halves of a soybean leaf, however, the soybean isolate, with 1 exception, was always the more pathogenic. The exception, isolate S3, was low in pathogenicity on soybeans and virtually nonpathogenic on tobacco.

A further test on the adaptation of tobacco and soybean isolates for their respective hosts was made by comparing the relative rates of multiplication of the bacteria in the leaves of each species. In each case, a soybean and a tobacco isolate were inoculated into opposite halves of the same leaf. Inoculum was sprayed forcibly against the lower leaf surface so as to watersoak large areas. After 3 days, 6 samples were taken from each half-leaf with a 4-mm cork borer, ground thoroughly in 10 ml of sterilized water, diluted appropriately, and plated on potato-dextrose agar (PDA). Colony counts were made after 5 or 6 days.

The results (Table 2) are in accord with those of the cross-inoculations, since each isolate attained a higher population level in the host from which it originally had been isolated.

To explore the possibility that a strain of the organism might become adapted to a new host, a soybean and a tobacco isolate of *Ps. tabaci* were maintained on each host through 3 successive transfers. The pathogenicity of the isolates was tested before and after the experiment. In addition, bacterial counts were made on PDA by plating leaf samples from each host after the first and third incubation period.

After repeated transfers to tobacco, the soybean strain showed a 40–62 per cent increase in pathogenicity for tobacco, and a 16–38 per cent decrease for soybeans. The tobacco strain, however, was reduced 50–100 per cent in virulence for tobacco after passage through soybeans, but its pathogenicity for soybeans appeared unchanged. Correspondingly, there was a marked increase (1000-fold) in the multiplication rate of the soybean isolate in tobacco leaves after repeated transfers to tobacco and a notable decrease (30-fold) in the multiplication rate of the tobacco isolate in soybean leaves after repeated transfers to soybeans. These results were confirmed in a second trial.

TABLE 2.—*Relative population levels of soybean and tobacco strains of Pseudomonas tabaci in the leaves of soybean and tobacco 3 days after inoculation*

Isolate[a]	Number of viable bacteria[b] per unit of leaf area in	
	Soybean	Tobacco
S1	433,000	833,000
T1	33,000	3,283,000
S2	2,050,000	
T2	783,000	
S5	211,000	160
T5	9,000	26,600

[a] Paired isolates were inoculated into opposite half leaves.
[b] Figures are the mean of 2 trials.

DISCUSSION AND CONCLUSIONS.—The evidence presented indicates that there are strains in *Ps. tabaci* differing in pathogenicity on tobacco and soybeans. These strain differences may explain why the wildfire disease does not spread readily from tobacco to soybeans. On the basis of the host specificity shown by the isolates tested, a typical well-developed wildfire lesion presumably indicates the presence of a strain of *Ps. tabaci* particularly adapted to the host on which it occurs. Limited evidence indicates that a soybean strain may become adapted to tobacco, and lose most of its pathogenicity for soybeans in the process. It seems unlikely, therefore, that a strain highly pathogenic on both soybeans and tobacco could be found on either host. Although there is no evidence to this effect, a possible source for such strains might be the roots of grasses (6) or some other similarly "neutral" medium where adaptation to parasitism on neither tobacco nor soybeans would be a factor.

Recently (5), the wildfire organism has been shown to multiply in the leaves of resistant plants. It was suggested that new strains of the organism pathogenic on plants now resistant might evolve. This might also explain the adaptation of the soybean strain to tobacco through mutation and selection.

Finally, the uniformly high pathogenicity of tobacco isolates on tobacco, in contrast with the erratic behavior of all isolates on soybean, makes it quite obvious that *Ps. tabaci* is a less virulent primary parasite on soybeans than it is on tobacco. The role of bacterial pustule (caused by *Xanthomonas phaseoli* var. *sojensis* (Hedges) Starr & Burk.) in inducing infection by the wildfire organism is treated in another paper (3).

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THE PEPPER VEINBANDING MOSAIC VIRUS IN THE EVERGLADES AREA OF SOUTH FLORIDA[1]

John N. Simons

SUMMARY

A possibly previously unreported virus disease of pepper (*Capsicum frutescens* L. var. California Wonder) was prevalent in the Everglades area of south Florida during the spring of 1954. Several species of the family Solanaceae were found to be susceptible. Of 11 species in 9 other families tested, only zinnia (Compositae) and purslane (Portulacaceae) were susceptible. The virus had the following physical properties: thermal inactivation point, 60°–65°C; dilution end-point, 1:10,000–1:20,000; and longevity *in vitro*, 10–15 days. Nightshade, *Solanum gracile* Link, was found to be a naturally infected weed source of the virus. Immunological studies with tobacco etch virus indicated no close relationship.

The green peach aphid, *Myzus persicae* (Sulz.), and the cotton aphid, *Aphis gossypii* Glover, were efficient experimental vectors, but the bean aphid, *A. rumicis* L., did not transmit the virus under the conditions used. The acquisition threshold period for the green peach aphid was between 0 and 5 seconds. Naturally terminated acquisition feedings resulted in more infections than did artificially terminated ones, but differences were apparent during only the first 15 seconds of feeding time. The inoculation threshold period for the green peach aphid was between 0 and 5 seconds. Increasing the test feeding period beyond 5 minutes resulted in only a slight increase in amount of transmission. Two-minute starvation periods following acquisition feeding caused a noticeable drop in infectivity in green peach aphids. One-hour periods resulted in almost complete loss of virus.

A severe disease of bell pepper was widespread in the Belle Glade area of the Everglades of south Florida during the winter and spring of 1953–54. Fields were observed in which large sections contained stunted plants (40–70 per cent) and which, as a consequence, produced negligible yields of marketable fruit. Estimates of crop loss ranged as high as 50 per cent.

Foliage of diseased plants was generally somewhat chlorotic and showed a marked veinbanding symptom (Fig. 1).[2] Infected fruit were roughened and displayed chlorotic spots and/or stripes (Fig. 2). Preliminary work indicated a sap-transmissible virus to be the causal agent of the disease, and this paper reports the results to date on work with this virus.

MATERIALS AND METHODS.—The virus was originally obtained from a diseased California Wonder pepper plant and was maintained in *Nicotiana tabacum* L. var. Turkish and *Capsicum frutescens* L. var. California Wonder. Seeds were germinated in sterilized sand or vermiculite, and the resulting seedlings were transplanted to 4-in. clay pots.

California Wonder pepper seedlings were used both as sources of inoculum and as test plants during the vector work. Insect transfers were made with a camel's-hair brush. The green peach aphid was maintained on caged healthy California Wonder pepper plants; the bean aphid was reared on caged healthy purslane plants (*Portulaca oleraca* L.); and the cotton aphid was maintained in moist chambers on healthy celery cuttings (*Apium graveolens* L. var. *dulce*, Golden Supreme). All aphid-feeding periods were observed with a hand lens and timed with a stopwatch. Plants were fumigated with nicotine before being placed in the greenhouse.

Mechanical inoculations were made with the aid of 500-mesh carborundum and cotton swabs. Undiluted, freshly expressed sap from recently infected Turkish tobacco plants was used as inoculum. Plants were rinsed with tap water immediately after inoculation had been completed. In carrying out the mechanical inoculations, test plants were used in groups of 5, and 5 replications per test species (total of 25 plants inoculated) were usually carried out. In cases where a high percentage of infection was obtained, less than 25 plants were sometimes used.

The average temperature in the greenhouse during this work was approximately 29°C.

HOST RANGE.—All plants used as test plants in the host range work were seedlings in either the cotyledon or 2- to 4-leaf stage. Definite symptoms of systemic infection were shown by the following species: zinnia (*Zinnia elegans* L.), pepper (*Capsicum frutescens* L. var. California Wonder, Yolo Wonder, Tabasco, and *longum*), tomato (*Lycopersicon esculentum* Mill. var. Rutgers and *cerasiforme*), *Nicotiana glutinosa* L., *N. tabacum* var. Turkish, horse nettle (*Solanum alaeagnifolium* Cav.), nightshade (*S. gracile* Link), and *Physalis peruviana* L. With the exception of zinnia, all of these species are in the family Solanaceae.

In addition, 2 species, purslane (*Portulaca oleraca* L.) and eggplant (*Solanum melongena* L.), apparent-

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The author is indebted to Mr. Henry Spellman for making the photographs and to Professor Erdman West for identifying certain of the weed material.

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[2] In 1946, E. I. Felix (4) reported a "mottling mosaic" of pepper. Nightshade was listed as a weed source without further elaboration. This disease may be similar to the one dealt with here.

ly were symptomless carriers. Virus was recovered from both noninoculated and inoculated leaves of these species although no symptoms were evident.

No evidence of infection was observed in inoculated plants of the following species (where the name is marked with an asterisk, attempts were made to recover the virus, and all were unsuccessful): spiny amaranth* (*Amaranthus spinosus* L.), swiss chard (*Beta vulgaris* var. *cicla*), *Commelina* sp., cabbage (*Brassica oleraca* L.), cucumber* (*Cucumis sativus* L.), crookneck squash (*Cucurbita pepo melopepo* Alef.), alfalfa (*Medicago sativa* L.), cowpea* (*Vigna sinesis* L. var. Blackeye), celery* (*Apium graveolens* L. var. *dulce*, Supreme Golden), sunflower* (*Helianthus annuus* L.), and jimsonweed* (*Datura stramonium* L.).

SYMPTOMATOLOGY.—In general, the initial symptoms shown in all of the hosts was a vein clearing in the young leaves, although this was much more pronounced in some species, e.g. Turkish tobacco, than in others such as zinnia or pepper. The terminal symptom in most species was that of veinbanding, but this was not true for every host. Initial symptoms in pepper appeared 7–10 days after inoculation. The veinbanding symptom (Fig. 1) appeared in about 3 weeks. In Turkish tobacco inoculated under the same conditions, symptoms first showed in 4–5 days (Fig. 3) and veinbanding did not appear for a month or more. In the greenhouse, shaded pepper plants developed more severe symptoms than did unshaded ones. A summation of the symptomatology and incubation periods in the various hosts is shown in Table 1.

PHYSICAL PROPERTIES.—In the determination of certain physical properties of the virus, Turkish tobacco was utilized both as source and test plant. Replicated trials using 4–5 plants per treatment were made.

In the determination of the thermal inactivation point, small cotton-stoppered test tubes containing 2 ml of freshly expressed refrigerated sap were heated in a hot water bath for 11 minutes (10 minutes plus

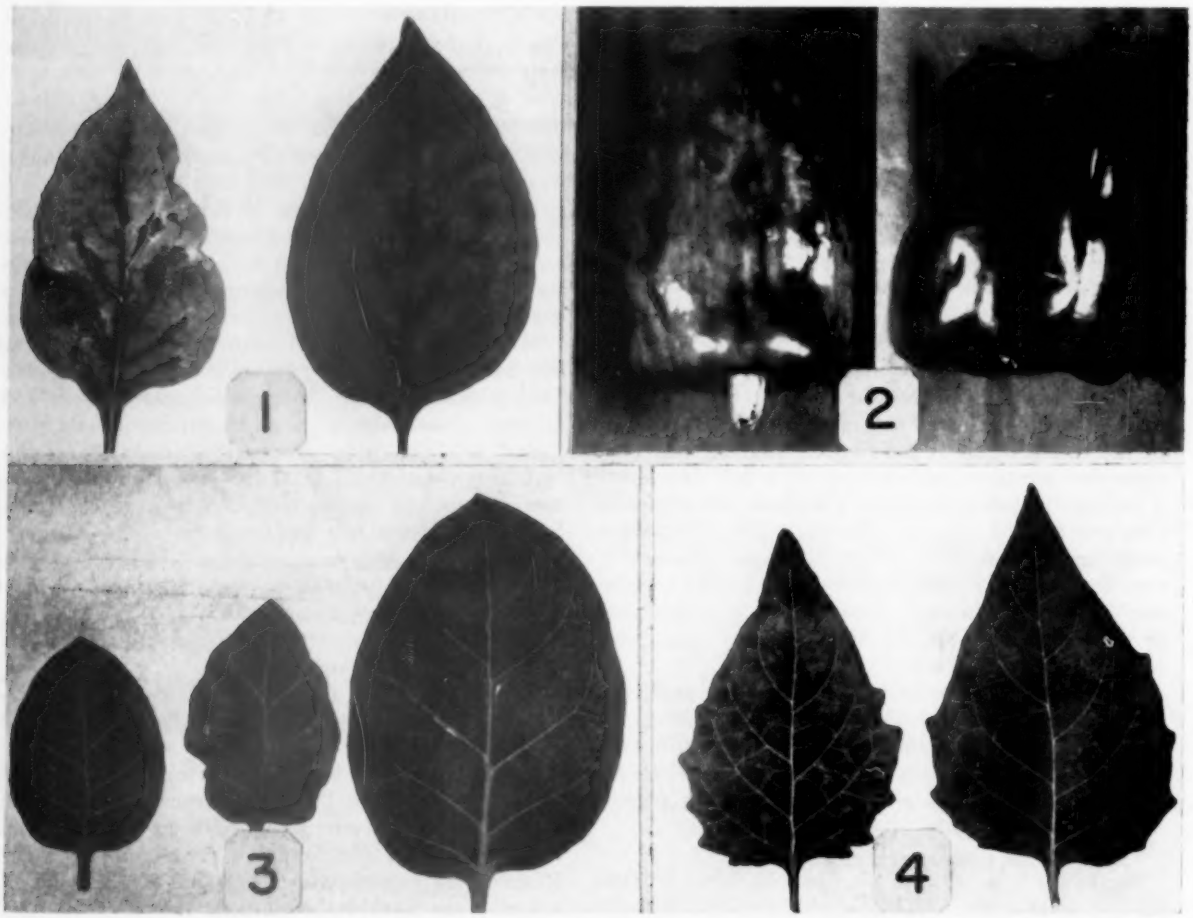

FIG. 1-4.—Fig. 1. California Wonder pepper leaf (left) diseased with pepper veinbanding mosaic virus. Note veinbanding and marginal crinkling. Healthy leaf is on the right.—Fig. 2. California Wonder pepper (left) infected with pepper veinbanding mosaic virus. Note the chlorotic striping and spotting and roughening produced. Healthy fruit is on the right.—Fig. 3. Turkish tobacco showing vein clearing (left), mottle, and cupping of leaf (center). Healthy leaf is on the right.—Fig. 4. Nightshade showing greenhouse symptoms of faint mottle and chlorotic spotting (left). Healthy leaf is on the right.

TABLE 1.—*Symptoms, incubation period, and recovery of pepper veinbanding virus in certain susceptible plant species*

Family and species	Plants showing symptoms[a]	Symptoms[b]	Average incubation period in days	Virus recovery attempt to Turkish tobacco[c]
Compositae				
Zinnia elegans L.	8/25	VC, MM	10	4/5
Portulacaceae				
Portulaca oleraca L.	0/25	None		2/5
Solanaceae				
Capsicum frutescens L.				
var. California Wonder	17/25	VC, SM, VB, LD	9	
var. Tabasco	5/5	VC, SM	10	
var. Yolo Wonder	5/5	VC, SM, VB, LD		
var. *longum*	5/5	VC, MM		
Lycopersicon esculentum Mill				
var. Rutgers	15/20	VC, MM, C	9	
var. *cerasiforme*	10/10	VC, MM, C	11	
Nicotiana glutinosa L.	15/15	VC, C, MM	5	
N. tabacum L. var. Turkish	25/25	VC, E, MM, LC, VB	4	
Solanum alaeagnifolium Cav.	5/5	VC, SM, VB	4	
S. gracile Link	5/5	VC, MM, LC	7	
S. melongena L.	0/25	None		1/10
Physalis peruviana L.[d]	25/25	VC, LD, MM, VB	12	5/5

[a] Numerator indicates number of plants infected, denominator the number inoculated.

[b] The letters indicate the following symptoms: C, leaves cupped downward; E, vein etching; LC, local chlorotic spots; LD, leaf distortion; MM, mild mottle; SM, severe mottle; VB, veinbanding; and VC, vein clearing. Order of use of letters indicates order of appearance of symptoms.

[c] Numerator is number of tobacco plants that became infected following inoculation with juice from noninoculated leaves of indicator plants, denominator is number of tobacco plants used as test plants.

1 minute to allow the sap to come up to temperature) at temperatures of 50°, 55°, 60°, 65°, and 70°C. The tubes were cooled in cold water immediately after completing the heating period. Results were as follows: 50°, 15 infected of 15 inoculated; 55°, 29/40; 60°, 11/40; 65°, 1/40; and 70°, 0/40. Because only 1 infection was obtained at 65°, 4 additional replications at 60° and 65° were carried out. Of 20 plants inoculated in each case, 11 became infected when rubbed with juice heated to 60°, and no infections were induced from juice heated to 65°. Consequently, the thermal inactivation point is probably between 60° and 65°C.

In the determination of the dilution end-point, freshly expressed sap was diluted in tap water and rubbed on leaves of Turkish tobacco plants. Results with the various dilutions were as follows: 1:500, 31 infected of 32 inoculated; 1:1000, 25/32; 1:5000, 5/32; 1:10,000, 6/32; and 1:20,000, 0/32. The dilution end-point would appear to lie between dilutions of 1:10,000 and 1:20,000.

Undiluted juice of infected tobacco plants was stored in cotton-stoppered test tubes at 23°C for various periods. Results were as follows: 1 day, 10 infected of 10 inoculated; 2 days, 19/20; 4 days, 10/20; 6 days, 27/40; 10 days, 7/40; 15 days, 0/40; and 20 days, 0/40. Virus infectivity was lost between 10 and 15 days.

IMMUNOLOGICAL RELATIONSHIPS.—Results of the host range and property studies indicated that, of the described pepper viruses, either tobacco etch virus (1, 6, 7), potato Y virus (8), or the pepper veinbanding mosaic virus (3) could be called suspect. All have host ranges restricted primarily to the Solanaceae and the physical properties of each are similar, although potato Y virus is generally reported as being more labile than the present virus.

Tobacco etch virus has been reported by Greenleaf (5) as producing a wilt reaction in tabasco pepper (*Capsicum frutescens* L.). Since the reaction of the veinbanding virus on this plant was a severe mottle, a cross-protection test seemed possible. Samples of known strains of both mild and severe etch viruses were obtained through the courtesy of Dr. C. W. Anderson, University of Florida, Gainesville, Florida. These were each mechanically inoculated from Turkish tobacco to young healthy tabasco plants, on which either produced a severe wilt symptom in about 7 days. Approximately 20 healthy tabasco plants were then inoculated with the veinbanding virus, and 10 days later half of these were inoculated with severe etch virus. Twelve days later all the plants that had been inoculated with both viruses had wilted, and none of the plants infected with veinbanding mosaic alone showed wilt symptoms. This procedure was repeated 3 times with similar results each time. The indication that the 2 viruses are closely related is not borne out from these results.

The values generally reported for the physical properties of potato virus Y (8) are lower than those found here for veinbanding mosaic virus. Also, insofar as the author is aware, the susceptibility of zinnia to potato Y is not established. *Datura stramonium* L. is generally regarded as not susceptible to Y virus strains, and that was found to be the case with veinbanding virus. Evidence presented here does not preclude the possibility of veinbanding mosaic being a strain of potato Y, but the differences appear to be sufficient to cause

hesitation in stating that this virus is a strain of Y. Possibly serological procedures would clarify the point. Since the description of the pepper veinbanding mosaic of Dale (3) agrees very closely in known characteristics with the disease reported here, and since that name is already established in the literature, the author proposes to use it in reference to the disease discussed in this paper.

VECTOR-VIRUS RELATIONSHIPS.—Preliminary tests indicated that veinbanding mosaic virus is aphid-borne, probably in a nonpersistent manner. Consequently, further studies were made of the vector-virus relationships.

Acquisition threshold period.—Groups of 20 noninfective, adult, apterous, green peach aphids were fasted for approximately 1 hour and then given artificially terminated acquisition feeding periods of 5, 10, 15, and 20 seconds. Twenty similarly treated green peach aphids were given acquisition feeding periods of natural length. In each case, the 20 aphids were grouped into 4 lots of 5. For purposes of randomization as to order of use, each lot of 5 was treated as a separate group in each of 9 replications. After completion of the acquisition feeding period, the insects were placed singly on healthy pepper seedlings and given test feedings of approximately 1 hour.

Aphids were able to acquire virus in 5 seconds or less (Table 2). The previously reported phenomenon (2, 9) of a decrease in vector efficiency from interruption of the acquisition feeding period was again demonstrated. This effect was clearly evident, however, only when the interruption occurred in 15 seconds or less. The high percentage of transmission obtained at the 9-and 10-second intervals would seem to substantiate Bradley's hypothesis (2) that acquisition feedings of only a few seconds duration may be sufficient to result in a high degree of infectivity if the insects remain undisturbed during this time.

Inoculation threshold period.—Noninfective, adult, apterous, green peach aphids were fasted for approximately 1 hour and were given timed acquisition feedings of natural length. They were then placed singly on healthy pepper seedlings for test feeding periods of various lengths. Five aphids were used at each timed interval per replication, and 8 replications were carried out. Results were as follows: 5 seconds, 1 plant infected of 40 fed upon (2.5 per cent); 10 seconds, 12/40 (30 per cent); 15 seconds, 12/40 (30 per cent); 5 minutes, 26/40 (65 per cent); 15 minutes, 23/40 (57.5 per cent); 30 minutes, 24/40 (60 per cent); 60 minutes, 31/40 (77.5 per cent); 120 minutes, 31/40 (77.5 per cent); 240 minutes, 31/40 (77.5 per cent); and 480 minutes, 30/40 (75 per cent). Percentage transmission increased with increase in length of test feeding up to 5 minutes; longer periods of feeding increased percentage transmission only slightly.

TABLE 2.—*Transmission of pepper veinbanding virus by green peach aphids given acquisition feeding periods of various lengths*

Length of acquisition feeding (seconds)	Number of test plants fed upon[a]	Percentage of test plants infected
(Artificially terminated feeding)		
5	45	6.6
10	45	33.3
15	45	53.3
20	45	60.0
(Naturally terminated feeding)		
9–11[b]	58	60.3
14–16[b]	37	67.6
18–22[b]	17	58.8

[a] One aphid per plant.
[b] All aphids in these groups had observed acquisition feeding periods that fell within the limits indicated.

Effect of starvation following acquisition feeding.—Adult, apterous, green peach aphids were fasted for approximately 1 hour and were then given naturally terminated acquisition feeding periods. Subsequently, they were placed in gelatin capsules for various intervals before being placed singly on healthy test plants. In addition, a nonfasted check group was used. Three aphids per time interval were used in each of 10 replications. Results were as follows: nonfasted check, 24 plants infected of 30 fed upon (80 per cent); 2 minutes fasting, 20/30 (66.7 per cent); 5 minutes, 13/29 (44.8 per cent); 10 minutes, 7/30 (23.3 per cent); 15 minutes, 9/30 (30 per cent); 30 minutes, 7/30 (23.3 per cent); 60 minutes, 1/30 (3.3 per cent); 120 minutes, 1/30 (3.3 per cent); and 240 minutes, 0/27 (0.0 per cent). (Where the denominator is less than 30, 1 or more test plants died.) Rate of virus loss was approximately logarithmic, and a noticeable effect was found after 2 minutes of fasting. The ability of a few aphids to retain virus for 2 hours would indicate that test feeding periods of up to 1 hour would give the maximum amount of transmission. A tendency towards this was shown in the preceding section where test feeding periods of 1 hour or more were somewhat more effective than shorter periods.

Vector efficiency.—Noninfective, adult, apterous aphids of 3 species were compared for vector efficiency. Green peach aphids, cotton aphids (*Aphis gossypii* Glover), and bean aphids (*A. rumicis* L.) were fasted for approximately 1 hour. They were then given timed naturally terminated acquisition feedings on diseased pepper after which they were transferred singly to healthy pepper seedlings for test feedings of about 1 hour. Five aphids of each species were utilized in each of 6 replications. The results were as follows: green peach aphid, 21 plants infected of 30 fed upon (70 per cent); cotton aphid, 16/30 (53.3 per cent); and the bean aphid, 0/25 (0.0 per cent).[3] It is evident that both the green peach aphid and cotton aphid can act as efficient vectors of veinbanding mosaic virus.

DISCUSSION.—From the evidence presented here, pepper veinbanding mosaic virus appears to be a typical nonpersistent aphid-borne virus (2, 9). The high

[3] The colony of bean aphids expired prior to completion of the last replication, thus only green peach and cotton aphids were used in this replication.

percentage of transmission obtained experimentally suggests that under field conditions virus spread could be rapid. Observations have supported this. Usually, the presence of nightshade (*Solanum gracile* Link) has been closely associated with occurrence of disease. Virus has not been recovered from any other naturally infected species to date. Symptoms on nightshade in the field are not always as pronounced as under greenhouse conditions; thus it is rather easy to overlook diseased plants at times (Fig. 4).

Although control procedures are still in the experimental stage, the apparently restricted weed-host range suggests the eradication of nightshade around pepper fields. Experiments in this regard are now being conducted. Several factors tend to complicate weed-control programs for pepper viruses in this area. One is the subtropical climate, which permits many normally annual plants to persist as semi-perennials. (Nightshade is one of these.) Another problem arises from the cultural necessity of having small drainage canals at intervals of 250–500 ft. across the field. The banks on these canals are often relatively unkept and harbor a large number of weeds. A third factor is the long growing season in the area. Peppers are often planted in late August and harvested from December to the following May or June. During this time, virus diseases can and do become serious, if not limiting, factors of production.

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PHYTOPATHOLOGICAL NOTES

A New Method for Screening First-year Potato Seedlings for Scab Resistance. T. Dykstra. In testing first-year potato seedlings for scab resistance in the greenhouse, an abundance of the disease-causing organism (*Streptomyces scabies* (Thaxt.) Waks. & Henrici) uniformally distributed in the growing medium is needed. In addition, the growing media should have a texture that permits plants to be pulled from it readily so that the tubers will remain attached to the stolons. Ordinary greenhouse soil has not been found satisfactory.

For several years, potato seed has been sowed in vermiculite in flats in the greenhouse at the Louisiana Agricultural Experiment Station. This medium has a fairly good waterholding capacity, it does not become compressed upon watering, and it permits each plant to develop an extensive root system that remains intact when the plants are pulled for transplanting.

It appeared that vermiculite infested with the scab organism would provide an ideal medium to use for testing transplanted seedlings for resistance to scab. In correspondence with Houghland and Cash, who had used vermiculite in their studies on control of scab in potatoes, the writer was informed of the method they had used successfully to obtain infection. Some time later this technique was published.[1] This method with some modification has been used in testing potato seedlings for scab resistance in the greenhouse at Baton Rouge, Louisiana.

Nitrate sucrose agar was prepared as follows: $NaNO_3$, 2 g; K_2HPO_4, 1 g; $MgSO_4 \cdot 7H_2O$, 0.5 g; KCL, 0.5 g; $FeSO_4 \cdot 7H_2O$, trace; sucrose, 30 g; water, 1000 ml; and agar, 15 g. The pH of the medium was 7.0.

About 40 ml of this medium was poured into each of a series of flat-surface bottles, which were sterilized and slanted. A water suspension of spores of *S. scabies* was poured on the hardened surface, and

[1] Houghland, G. V. C., and L. C. Cash. 1954. The use of vermiculite in providing scab inoculation for potatoes. U. S. Dept. Agr. Pl. Dis. Rptr. 38: 460-461.

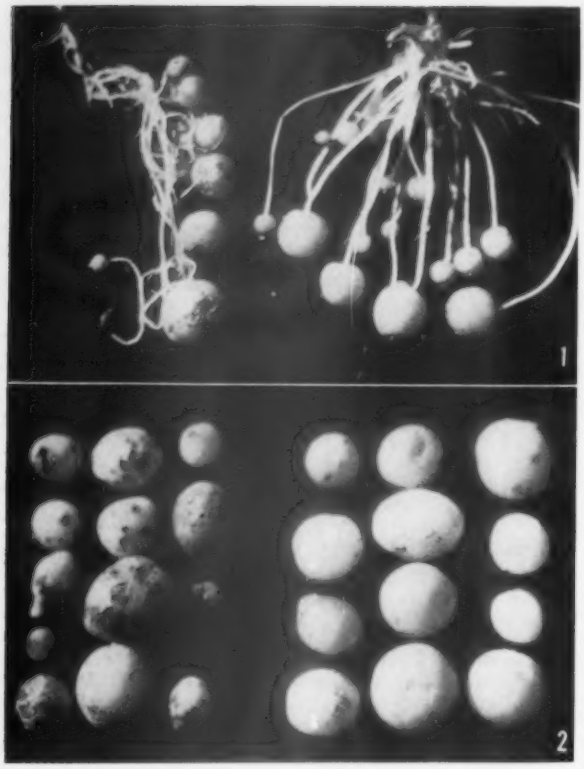

FIG. 1–2.—Fig. 1. First-year potato seedlings pulled from vermiculite infested with *S. scabies*. Tubers of plant on left show scab lesions. Seedling on right was an adjoining plant from some progeny highly resistant to scab.—Fig. 2. Tubers on left come from scab-susceptible seedlings grown in vermiculite infested with *S. scabies*. The ones on the right are from adjoining plants highly resistant to scab.

within 48 hours abundant growth of the organism could be observed on the slant. After 1 week of growth, 60 ml of water was added to each bottle. Then the entire contents of each bottle were placed in an electric blender and blended for about 3 minutes. The contents of 20 such bottles, or a total of about 2000 ml, were mixed thoroughly with 20 lb. of vermiculite containing a small amount of complete fertilizer. Ideal growing conditions for the scab organism were provided by the addition of the blended mixture of agar and mycelial mat to the vermiculite.

The inoculum was mixed uniformly with the vermiculite. Twenty lb. of vermiculite was spread on the floor in a layer about 6 in. thick. Three gal. of water was sprinkled uniformly on the vermiculite with a sprinkling can. After thorough stirring, the mixture was flattened again to a depth of 6 in. The inoculum was then poured uniformly over the moist vermiculite which was then mixed thoroughly. Moistening the dry vermiculite previous to addition of inoculum facilitated the obtaining of a uniform distribution of the scab organism.

A 5-in. layer of infested vermiculite was placed in a greenhouse bench. Seedlings 1–2 in. tall were transplanted to this, and were spaced about 2 in. apart each way. Only progenies that had at least 1 parent resistant to scab were tested.

The first symptoms of scab could be detected on tubers the size of a pea. After tubers were of sufficient size to be used for seed (Fig. 1, 2), each plant with its tubers attached to the stolons was pulled intact from the vermiculite. Tubers were then examined for scab. Plants can be pulled easily if the vermiculite is thoroughly wetted. By use of this method, it is easy to select and save tubers from scab-resistant seedlings and to avoid a mixture of tubers from adjoining plants.

If a cross was made primarily for the purpose of obtaining a scab-resistant variety, all susceptible tubers were discarded, and only tubers showing a high degree of resistance were saved. If a cross was made to transmit multiple characters such as scab resistance, blight resistance, or color, some seedlings susceptible to scab were saved for other tests.

The described method of testing for scab resistance makes it possible to obtain definite information on degree of scab resistance of individual seedlings only a few months after true seed is sowed. The tubers from both the resistant and the susceptible seedlings may be saved, if so desired, to test for additional characters, with a full knowledge of their genetic reaction to scab already established.—Horticultural Research Branch, Agricultural Research Service, U. S. Department of Agriculture, and Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana.

Longevity of Cercospora kikuchii on Soybean Stems. R. A. KILPATRICK[1]. Soybean stems heavily infected with *Cercospora kikuchii*[2] were collected from field plots at Stoneville, Mississippi, in October, 1951[3]. These were tied in a bundle and hung outside the laboratory window. At 6-month intervals thereafter, sections of stems were removed from the bundle and incubated in a moist chamber for 48 hours. Lesions were then examined for sporulation of the fungus.

Conidia of *C. kikuchii* were very abundant during the first 18 months, generally decreasing in number with each successive period of examination. After 42 months, however, the fungus could still be isolated from stem sections, suggesting that the fungus can survive on plant debris for a number of years. It would appear that the fungus over-winters on stem lesions as well as on seed.—Delta Branch, Mississippi Agricultural Experiment Station, Stoneville, Mississippi.

[1] Pathologist, Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

[2] Infected stems were sent to Dr. C. Chupp who identified the fungus as *C. kikuchii* (T. Matsu. & Tomoyasu) Gardner.

[3] Johnson, H. W., and R. A. Kilpatrick. 1953. Soybean diseases in Mississippi in 1951-52. U. S. Dept. Agr. Pl. Dis. Rptr. 37: 154-155.